Diversion Effects on Fish

Issues and Impacts

Prepared by the

CALFED Diversion Effects on Fish Team

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EXECUTIVE OVERVIEW

An interagency/stakeholder Diversion Effects on Fish Team (DEFT) was formed to address the technical issues related to diversion impacts on fisheries for each the CALFED alternatives. The primary issues addressed were:

- Which species, populations, and life stages are most sensitive to diversion effects under no action and alternatives 1, 2, and 3?
- What degree of benefit and impact will the common programs provide?
- What is the risk and chances of success of species recovery for each alternative?

To evaluate these issues, species teams were formed for salmon, striped bass, and delta smelt. These species were chosen because they represent a range of exposure periods and they are the objects of numerous management and regulatory concerns. There are species that may be affected by changes in delta conditions whose responses may differ from the species analyzed here. The species teams developed matrixes on the effects of a set of impact parameters on the life stages of each species by month for each alternative. The detailed matrixes are described in individual species reports appended, which the reader is strongly urged to review for the details of the evaluations. This report summaries the process, assumptions, modeling studies, information used, professional judgement and the conclusions reached by the teams.

This report and the results should be interpreted cautiously, recognizing the many informational and procedural limitations inherent in these work products. The short time frame provided for this work compelled the team to rely primarily on professional judgement to evaluate the degree to which each relevant factor affects each of the key species. Assumptions had to made that in some cases limited the teams ability to answer the primary issues and included: 1) evaluation of diversion effects on fish populations was confined to the legally defined Delta, Suisun Bay and Suisun Marsh, even thought the CALFED solution area is much larger; 2) evaluations were based on a single operations study for each scenario with no attempt to minimize impacts or maximize benefits, (The next phase of the teams efforts will be to optimize the alternatives.), 3) the common programs will provide benefits with some negative impacts to each of the evaluated species, but the quantification of these benefits is uncertain, and 4) the impacts of water quality and exotics issues have not been evaluated.

The following were consensus professional judgements of the species teams, based on system operations modeling studies and published and unpublished information on individual species biology. Although the team had consensus on a number of assumptions regarding delta species biology, opinions of other scientists on the validity of the assumptions will likely vary from consensus to strong disagreement. The outcome of the assessments is very dependent on these assumptions.

The **salmon** team evaluated relative survival in the Delta of chinook salmon from the Sacramento and San Joaquin basins; Sacramento River races were assessed in aggregate. Survival was estimated monthly in relation to impact parameters considered important to salmon survival in the Delta. For Sacramento River chinook, five composite parameters had the greatest effects on survival; 1) entrainment losses, 2) flows below a Hood diversion, 3) interior-Delta survival, 4) habitat restoration, food supply, and screening of small agricultural diversions, and 5) impacts on adult upstream migration. Common Programs, Alternative 1, and Alternative 3 had similar total impacts, but involved different tradeoffs among benefits and detriments to salmon survival. Alternative 2 was least favorable, largely due to anticipated increases in adult straying and migration delays. For all three Alternatives, Common Programs provided most of the benefit. For San Joaquin salmon, the key composite parameters were 1) entrainment losses, 2) flow at Vernalis, 3) interior-Delta survival, and 4) habitat restoration, food supply, and screening of small agricultural diversions. Alternative 3 offers the greatest benefits for San Joaquin salmon, exceeding the benefits of any alternative for Sacramento salmon. Benefits accrue through reduced entrainment and improved interior-Delta survival.

The **striped bass** team concluded that none of the alternatives are likely to restore the adult population to historic levels (i.e., population of 1.8-3 million). Alternative 3 provides the best potential for partial restoration of the population. Alternative 3 is likely to reduce the entrainment of juveniles at the south Delta export facilities and increase the salvage of those that are entrained. Alternative 3 will likely enhance the transport of eggs and larvae in the lower San Joaquin River by positive flows and also restore Delta nursery habitat. However, both Alternatives 2 and 3 may have negative impacts by decreasing egg and larva transport below the Hood intake. Alternative 2 also has high impacts because of passage problems created for adult fish using the Mokelumne River as a migration route to Sacramento River spawning grounds. Alternative 2 also subjects eggs and larvae to two diversion points. Alternative 1 is likely to increase the entrainment of eggs and larvae at the south Delta export facilities. The common programs have both potential benefits and detriments that were difficult to quantify but are likely to have some net benefit.

The **delta smelt** team concluded that Alternative 3 has the most potential to improve conditions for delta smelt; however, the uncertainty associated with this evaluation is extremely high. The delta smelt team made separate evaluations for wet years and dry years. The No Action Alternative results in a slight worsening of conditions in both year types because of increased diversions to meet increased demand. The Common Programs result in a moderate improvement in conditions in both year types because of hypothesized benefits associated with increases in shallow-water habitat. Alternatives 1 and 2 represented moderate improvements compared to existing conditions but the benefits are derived from the Common Programs rather than changes in conveyance associated with the alternatives. Alternative 1 resulted in a slight decline in value in relation to the Common Programs. Alternative 2 resulted in a moderate decline in the value in relation to the Common Programs. The hydrodynamic effects of Alternative 2 were believed to be a strong negative effect on delta smelt. Alternative 3 resulted in significant benefit to delta smelt because of the combination of the positive effects of the Common Programs and the Team's assessment that the hydrodynamic effects would also be positive for the majority of the population. The degree of benefit from the three Alternatives is very dependent on the Common Programs; thus, different assumptions about benefits of the Common Programs could result in substantially different assessments.

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1. INTRODUCTION

An interagency/stakeholder Diversion Effects on Fish Team (DEFT) was formed to addressed the technical issues related to diversion impacts on fisheries for each the CALFED alternatives. The primary issues addressed were:

- Which species, populations, and life stages are most sensitive to diversion effects under no action and alternatives 1, 2, and 3? When and where are they most affected?
- What degree of benefit and impact will the common programs provide?
- What is the risk and chances of success of species recovery for each alternative?

To provide a base to evaluate the these issues, interagency/stakeholder species sub-teams were formed for salmon, striped Bass, and delta smelt. This report summaries the organization, process, assumptions, modeling studies, information used, professional judgement and the conclusions reached by these species teams and the full DEFT.

Team Organization

Members of the DEFT are listed below under the species team on which they primarily served. Some participated in several teams. Several people contributed to the species teams that are not on the DEFT. They are identified with an (*).

Salmon team
Patricia Brandes (co-chair), U.S. Fish and Wildlife Service
Shelia Greene (co-chair), Department of Water Resources
Serge Birk, Central Valley Project Water Association
Pete Chadwick, Department of Fish and Game
Karl Halupka, U.S. National Marine Fisheries Service
Jim White, Department of Fish and Game
*Jim Starr, Department of Fish and Game
Striped Bass Team
Lee Miller (chair), Department of Fish and Game
Elise Holland, Bay Institute
*Stephani Spaar, Department of Water Resources
*David Kohlhorst, Department of Fish and Game
Kevan Urquhart, Department of Fish and Game
*Don Stevens, Department of Fish and Game
Delta Smelt Team
Dale Sweetnam (co-chair), Department of Fish and Game
Larry Brown (co-chair), U.S. Bureau of Reclamation
Michael Thabault, U.S. Fish and Wildlife Service
*Chuck Hanson, State Water Contractors
DEFT members not on a specific species team
Bruce Herbold, U.S. Environmental Protection Agency

Pete Rhoads, Metropolitan Water District Southern California
Michael Fris, U.S. Fish and Wildlife Service
Jim Buell, Metropolitan Water District Southern California
Ron Ott, CALFED

Process

To guide the species teams and to provide a framework for addressing the issues the DEFT developed a list of impact parameters that have direct and indirect effects on the populations in the Delta. Each species team modified the impact parameters listed below to better assess the impacts on their particular specie. The general impact variables are:

- Entrainment
- Hydrodynamics
- Predation
- Handing
- Food Supply
- Shallow/near shore Habitat
- Water Quality (Contaminants)
- Water Quality (Temperature)
- Water Quality (Salinity)
- Agriculture Diversions
- Straying

Each species team evaluated the impacts and benefits on their species against the above parameters for each month of the year for:

- Exiting Conditions
- No Action
- Common Programs
- Alternative 1
- Alternative 2
- Alternative 3

These alternatives are described in the CALFED document, "Programmatic EIS/EIR, Technical Appendix-Phase II Report", March 1998
Sacramento and San Joaquin salmon represent anadromous species with the shortest exposures to delta conditions. Striped bass, an anadromous species, and delta smelt, a resident species, represent species with greater exposure to delta conditions.

The species teams developed matrixes on the effects of the impact parameters on the life stages of each species by month for each alternative. These were used by the teams to address the primary listed above and other issues listed below. The detailed matrixes and interpretations are described in individual species reports in Appendices 1,2 & 3. Species teams reports were review by the DEFT and other stakeholders outside the DEFT.

Other Issues

This report focuses on primary issues 1, 7, and 5. In addressing these three primary issues the species teams also answered several other issues, numbered below. All others except issues 4 and 13 were addressed in the individual species report (Appendices 1,2&3). Issues 4 and 13 will be addressed in the next phase of this teams efforts. The issues are:

1. Which species, populations, and life stages are most sensitive to diversion effects under no action and alternatives 1, 2, and 3? When and where are they most affected?
2. Can diversion effects in the South Delta be offset by habitat improvements and other common program actions?
3. To what extent can alternatives 1, 2, and 3 offset diversions effects as presently configured?
4. To what extent can diversion effects be offset by modifications to the alternatives or by operational changes? (Will be addressed in biological operation criteria white paper.)
5. What is the risk and chances of success of species recovery for each alternative?
6. What increment of protection or improvement for fish species will be provided by other programs such as the Central Valley Project Improvement Act, biological opinions, etc.?
7. What degree of benefit and impact will the common programs provide?
8. What are the direct and indirect effects on fish populations resulting from each alternative and what is the expected response of the populations to these effects?
9. What Sacramento River flow is required below a Hood diversion to protect salmon, striped bass and delta smelt?
10. What survival rate can be expected for striped bass eggs and larvae and delta smelt passing through Sacramento River screen and pumps in Alternative 2?
11. Should there be a screen on the Sacramento River intake of Alternative 2?
12. What are the logical stages for a preferred alternative? (Will be address in biological operation criteria white paper.)
13. What is the range of biological criteria that should be considered in operations of the three alternatives? (Will be addressed in biological operation criteria white paper.)

2. ASSUMPTIONS AND LIMITATIONS

This report and the results should be interpreted cautiously, recognizing the many informational and procedural limitations inherent in these work products. The short time frame provided for this work compelled the team to rely primarily on professional judgement to evaluate the degree to which each relevant factor affects each of the key species. Assumptions had to made that in some cases limited the teams ability to answer the primary issues. The assumptions and limitations are summarized below.

Biological Scope

The team has analyzed the impacts of different CALFED scenarios using the three species that represent types of fish likely to be affected. Some species, such as those that live their entire lives upstream or downstream of the delta are unlikely to be affected by changes in point of diversion in the delta. Other species, such as tule perch or largemouth bass, have life history characteristics that make them much less sensitive to hydrodynamic conditions or entrainment were also excluded. The three species the team examined included Sacramento and San Joaquin salmon to represent anadromous species with the shortest exposure to delta conditions. Striped bass, an anadromous species, and delta smelt, a resident species, represent species with greater exposure to delta conditions. Other species that may be affected by changes in delta conditions, but whose responses may differ from the species analyzed here, include: green sturgeon, white sturgeon, longfin smelt, Sacramento splittail, and American shad. CALFED may need to develop a future analysis to address these species.

Geographic Scope

The geographic scope of the CALFED "solution area" encompasses all of the Central Valley, San Pablo and San Francisco bays, and the near-shore Pacific ocean. The team's evaluation of diversion effects on fish populations was confined to the legally defined Delta, Suisun Bay and Suisun Marsh. Consequently, the team did not incorporate into its evaluation the potential beneficial and adverse effects of actions outside that area. Fluctuations in ocean and bay conditions, salmon and striped bass harvest management, CALFED's Ecosystem Restoration and Water Quality programs that occur outside the delta, and actions associated with the Central Valley Project Improvement Act (CVPIA) are all likely to affect fish populations.

Restoration and recovery of these three species will also depend on CALFED actions outside of the "problem identification area" that the team has addressed. CALFED's actions must also address many issues of greater uncertainty than those addressed, such as offshore harvest. Therefore, the team was unable to assess the degree to which the effects of these delta-based scenarios contribute to overall restoration and recovery. A far more complex and time-consuming analysis would be necessary to integrate the Delta effects we identify, with the broader range of natural fluctuations and human activities that will determine recovery.

The team identified the principal mechanisms by which storage and conveyance will affect these species, when these species are in the Delta. The team assigned relative ranks to summarize it's assessments of the balance of impacts and benefits for each scenario.

Process

Evaluations were based on the team's best professional judgement to the degree of which each relevant parameter affects each key species. The judgements considered empirical relationships between parameters and survival, where such relationships were available. Evaluations were based on operations modeling studies and qualitative assessments of the degree to which water operations, water management facilities, and biological parameters affect the populations of each species. More rigorous quantitative analysis was not possible within the time constraints imposed on this process.

The evaluations recognized the many sources of uncertainty that derive from the limitations of our scientific knowledge about the species and Bay-Delta ecosystem. From an analytical perspective, monthly averaged hydrology was the primary hydrologic parameter used in the analysis. For example, the use of particle tracking model output, which is based on short time-steps, may help reduce this uncertainty.

Sources of uncertainty on biological processes takes a variety of forms and makes any predictions of actual results at the population level extremely problematic. For example, the benefits of shallow water habitat to Delta smelt are not yet well understood. With regard to striped bass, the continuation of historic relationships into the future is unclear due to the many changes in the system. For salmon, the sources of mortality in the Delta are poorly understood. The various sources of uncertainty were acknowledged, identified, and considered to the extent possible in the evaluation

Procedures and Inputs

Evaluations are based on a single operations study for each scenario. There has been no attempt to minimize impacts or maximize benefits. The next phase of the teams efforts will be to optimize the alternatives. The specific CALFED operations studies used for each scenario were: Existing Conditions-558, NoAction-516, Alternative 1 without storage-518, Alternative 1 with storage-609, Alternative 2 without storage-528, Alternative 2 with storage-532a, Alternative 3 without storage-595, and Alternative 3 with storage-567. These runs included meeting the flow requirements for the Vernalis Adaptive Management Plan (VAMP), meeting the 1995 WQCP, and the biological opinions for delta smelt and winter-run chinook salmon. Analyses were based on monthly flows at selected locations in the Delta averaged over all years and averaged over selected dry and critical years. No attempt was made to explore the full range of annual variability

Using the model runs above, each alternative was analyzed by the salmon team with no new storage and with maximum new storage. The delta smelt and striped bass teams analyzed the no new storage alternatives only. The range of storage represents the extremes of existing storage to an additional 6.2 MAF of new storage. Storage between these two extremes would have marked results on the outcome of these evaluations. There was no attempt to minimize impacts or maximize benefits by optimizing storage.

For each alternative, the model runs produced average monthly flows at locations throughout the Delta. Wet and dry year flow summaries were used in the evaluation of impacts of an alternative. In some cases , using average monthly flows and monthly summaries could minimize the actual impacts or benefits of an alternative. The team attempted to account for the model limitations in their evaluations.

Incorporation of Common Programs

The evaluation of the effects of the Common Programs posed particular challenges for this evaluation. For example, at the current programmatic level of development, the distribution of restored/rehabilitated wetland and riparian habitat has not been defined. Different distributions of habitat would benefit different species. However, even if the distribution were clearly defined, our current level of scientific knowledge limits the evaluation of the benefits that would accrue to each species.

There was a broad consensus among the team that the common programs will provide benefits to each of the evaluated species. The quantification of these benefits is, however, not possible at this time. Increasing the amount of habitat will almost certainly increase the potential for survival of each of the evaluated species, but the magnitude of the increase is uncertain. Some potential impacts of the water quality program on striped bass are considered.

Water Quality

Changes in point of diversion would effect a variety of water quality parameters in the Delta. San Joaquin River water carries a significant load of agricultural chemicals, selenium, and other contaminants and nutrients. Sacramento River water generally carries lower loads and carries different metals such as copper, mercury, cadmium and zinc. Delta water directly receives a variety of agricultural chemicals (including herbicides), salts and organic carbon. Contaminant loads and concentrations vary seasonally, vary with hydrology, and can be expected to vary with different points of diversion and changes in operating criteria. The availability and effects of these chemicals on fish populations, and the food web that supports them, are unknown but potentially significant. Impacts may occur through direct toxicity, but are more likely through chronic effects or trophic disruptions. Synergisms of chronic effects with other factors such as disease or reduced growth that prolongs exposure to predators may also result in effects on fish populations. Changes in the point of diversion could also affect the transport of ocean derived salts in the Delta. The DEFT has not attempted to incorporate any of these contaminant effects into the evaluations of fishery impacts , and recommends collaborative efforts of the ecosystem restoration and water quality program elements to address these concerns as part of the plan for implementing the first phase of the CALFED program. A small group of appropriate experts from the water quality team and the DEFT should meet to evaluate these factors and help the

DEFT revise the present report.

Exotics

The Bay/Delta is dominated by non-native species. Some introduced species have substantially altered the functioning of ecosystems they have invaded and the team has limited understanding of the new ecological relationships among species. New species will likely continue to arrive and disrupt the biological communities of the estuary in the future. All data and analyses, therefore, that rely on historical relationships may not predict the future but they are the only available basis for analysis. The almost certain arrival of new species in the future may alter the ability of the estuary to support these three species but the group feels it is unlikely that effects of new species introductions would change the performance of the alternatives relative to each other ,in that, species introductions would not fundamentally alter the response of a fish population to basic ecosystem properties such as spawning habitat, streamflow, or hydrodynamics.

3. PRIMARY QUESTIONS

Each of the species team addressed the primary and other issues in their species reports in Appendices 1, 2 and 3. Summary evaluations of the primary questions (1, 7, and 5) for each species follow.

Salmon

1) Which species, populations, and life stages are most sensitive to diversion effects under existing conditions No Action and Alternatives 1, 2, and 3? When and where are they most affected?

The salmon Team evaluated diversion effects in the Delta on San Joaquin basin chinook salmon and an aggregate of all races of Sacramento-basin chinook. All San Joaquin chinook migrate through the south Delta, where they experience direct entrainment, loss in Clifton Court Forebay, and reduced survival associated with unfavorable flow distributions. A much smaller portion of Sacramento chinook are affected by diversions from the south Delta.

Substantial negative effects exist for both groups under existing conditions, and those would persist under No Action and Alternative 1, although direct entrainment losses would be reduced by a small increment under Alternative 1. Under Alternatives 2 and 3, the entire population of Sacramento chinook would emigrate past a screened diversion at Hood, and would be exposed to flow reductions in the Sacramento River downstream of Hood. Adverse effects unique to Alternative 2 would be increased straying and migratory delay of adult salmon returning to the Sacramento basin, due to both attraction to the Mokelumne River portion of the Delta and exposure to a fish passage facility at the Hood diversion. Under Alternative 2, direct and indirect effects in the San Joaquin portion of the Delta would be less for salmon from both rivers. Those effects would be further reduced under Alternative 3.

Fry rearing in the Delta is important to salmon production, especially in wet years. Diversion effects are believed to be greater on actively migrating yearlings and smolts, whether rearing takes place in the Delta or in upstream areas.

7) What degree of benefit and impact will the Common Programs provide?

Much of the expected benefit for salmon would result from restoration of shallow water habitat. However, the actual effect on salmon populations is uncertain. Salmon pre-smolts are particularly likely to use restored habitats. Restored habitats would also be favorable for predators but in the opinion of most salmon biologists the increased cover and food supply should increase salmon survival and provide net benefits. If habitat restoration is successfully implemented along migration corridors for salmon, benefits should be greater than estimated in this analysis. Screening Delta diversions and improved Delta water quality are also expected to be beneficial. Increased spring flows would slightly improve chinook survival in the Delta, in addition to providing upstream benefits. The Water Use Efficiency and Water Transfer programs would increase flexibility in water supply operations, offering some opportunities to shift diversions to times less detrimental to salmon, but such shifts would probably increase impacts on other species. Overall, the Common Programs are unlikely to provide sufficient benefits in the Delta to offset diversion effects fully.

5) What are the risks and chances of success of species recovery for each alternative?

Recovery depends on conditions throughout the life history of salmon. Because the salmon team considered only needs of juveniles and adults in the Delta, the following answers are more appropriate for addressing risks of precluding recovery by significantly adversely impacting one lifestage, rather than addressing the chances of success of species recovery.

No Action - Substantial adverse impacts to San Joaquin chinook in the south Delta under Existing Conditions would increase under No Action due to the increased exports from the south Delta. Although a smaller proportion of the Sacramento chinook are impacted by south Delta exports, substantial negative effects exist for both groups under existing conditions, and those would persist under No Action. The operation studies provided for these analyses assume the Delta Cross Channel gates are closed between November and June to improve survival of salmon migrating down the Sacramento River. The validity of this assumption during November and December was questioned by the salmon team since water quality objectives often are in conflict during low flow periods. The ongoing efforts of the Ops Group to improve salmon survival under Existing Conditions in the face of limited operational flexibility, and the probable decrease in flexibility over time with the No Action scenario, indicate potential for precluding recovery.

Alternative 1- Delta Cross Channel gate closure to improve survival of salmon emigrating down the Sacramento River would continue to be in conflict with water quality objectives during low flow periods. Improved fish screens in the south Delta would provide additional protection, especially for San Joaquin salmon. These benefits would be tempered by the continued need for handling and trucking, but this is less of a risk for salmon than for many other species. Overall, reduced entrainment and benefits from the Common Programs probably would not be sufficient to cause major improvements in salmon production.

Alternative 2- The diversion at Hood would impose several new risks for salmon from the Sacramento system (see response to question 1 above). The salmon team believes that Alternative 2 would pose risks for salmon from the Sacramento system greater than any other alternative, potentially resulting in population declines relative to Existing Conditions. For salmon from the San Joaquin, the combination of improved flow distribution in the central Delta, and benefits from new screens in the south Delta (see Alternative 1), would make Alternative 2 superior to Alternative 1.

Alternative 3- For Sacramento salmon, Alternative 3 would not pose the same risk for upstream migrants as Alternative 2. Other risks of the Hood diversion would be essentially the same as those described for Alternative 2. These risks would result in overall benefits about the same as for the Common Programs. San Joaquin basin chinook have the greatest potential to benefit from Alternative 3. The benefit that would be most certain is the reduction in entrainment losses associated with the large reduction in diversions from the south Delta.

Striped Bass

1) Which species, populations, and life stages are most sensitive to diversion effects under existing conditions No Action and Alternatives 1, 2, and 3? When and where are they most affected?

No Action- Striped bass eggs, larvae, and juveniles are directly impacted by water diversions in the Delta during the first year of life from April through fall, and sometimes during winter. The impact on eggs and young fish occurs from April to July, with further impacts on larger juveniles through summer and fall. Under current conditions, the population is likely to continue to decline in the absence of a stocking program. In recent years, young striped bass abundance has remained low despite higher-than-average delta outflows and low export rates, both of which are conducive to strong year classes in the past.

Alternative 1- Entrainment of eggs, larvae, and juveniles in the south Delta will continue and increase with channel improvements and additional storage. Closure of the cross channel gates through the spawning season from April to June would reduce the diversion of Sacramento River striped bass eggs and larvae but may cause increased flow reversal in the lower San Joaquin River.

Alternative 2- Increased numbers of eggs and larvae could be diverted and entrained from the Sacramento River because fish screens at the Hood diversion would be inadequate to screen these stages. The magnitude of diversion of eggs and larvae from both the Sacramento and San Joaquin rivers, as well as juveniles from the San Joaquin, depends on operation of the facilities. For example, temporary reduction in diversion at Hood during the striped bass spawning season would reduce diversion of eggs and larva from the Sacramento River and provide transport flow to move young bass to the nursery areas downstream. At the Clifton Court diversion, eggs, larvae, and juveniles would be continue to be entrained; more juveniles would be salvaged.

Adults would be attracted by the high proportion of Sacramento water in the Mokelumne River and they would be trapped behind the fish screen at Hood. The feasibility of passing large numbers of striped bass around or over such structures is highly questionable. Adults trapped behind the Hood fish screen would be forced to spawn in the Mokelumne River and most of their progeny would be entrained in the flow to the export pumps. If flow diverted at Hood is a large proportion of the Sacramento flow, as might occur in dry years, more fish would be attracted to the Mokelumne as a corridor to the spawning grounds.

Alternative 3- Increased numbers of eggs and larvae could be diverted and entrained from the Sacramento River because fish screens at the Hood diversion would be inadequate to screen these stages. The magnitude of diversion of eggs and larvae from both the Sacramento and San Joaquin rivers, as well as juveniles from the San Joaquin, depends on operation of the facilities. For example, temporary reduction in diversion at Hood during the striped bass spawning season would reduce diversion of eggs and larva from the Sacramento River and provide transport flow to move young bass to the nursery areas downstream. If diversions are not curtailed entrainment of egg and larva will be high and transport flows will likely be inadequate. Adult migrations would not be affected as for Alternative 2 because the facility is isolated. Because QWEST flows would be improved over existing conditions and less water would be diverted from the south Delta, the team expects less entrainment of striped bass and improvement of nursery habitat in the Delta.

7) What degree of benefit and impact will the Common Programs provide?

The common programs will likely provide some benefits to young striped bass, but these are difficult to quantify. Screening of small Agricultural diversions would reduce mortality of young striped bass. Increasing the amount of marsh habitat for nursery areas adjacent to Suisun Bay and in San Pablo Bay would likely increase survival of young striped bass. Reducing point and non-point sources of toxic chemicals and metals could improve conditions for all life stages to some degree; however, present population impacts of toxicants have not been demonstrated. Reduction of organic input and decreasing turbidity may adversely affect striped bass production.

5) What are the risks and chances of success of species recovery for each alternative?

When and where are they most affected? The adult population is affected by reduced recruitment as a result of early life stage losses. Although there is evidence of density-dependent survival (compensation) it has not been sufficient to maintain the numbers of adults that were historically present. Recovery cannot occur under the No Action Alternative. Alternatives 1 and 2 appear to exacerbate present problems associated with using the Delta as a water export conduit. Alternative 3, while falling short of restoration to historic population levels, would, if operated in a manner which minimized entrainment of young striped bass and provided adequate transport flows, provide the best opportunity for partial restoration of the population.

Delta Smelt

1) Which species, populations, and life stages are most sensitive to diversion effects under existing conditions No Action and Alternatives 1, 2, and 3? When and where are they most affected?

No Action: Larvae and young juveniles are the most sensitive life stages. These life stages are present in the spring and early summer. The major effects occur in the central and south Delta where altered hydrodynamics and entrainment are important. As delta smelt become adults, they migrate downstream to brackish water areas in the fall and winter and are considered less vulnerable to diversion effects. Pre-spawning adults migrating back into freshwater to spawn in the late winter and early spring become vulnerable to entrainment effects once again.

Alternative 1: The same as No Action.

Alternative 2: Larvae and young juveniles are still the most sensitive stages and are still vulnerable at the same times. The major changes in hydrodynamics anticipated with Alternative 2 are believed to be a negative factor for all life stages of delta smelt, but especially these sensitive stages. These negative effects are expected to be most severe in the eastern Delta.

Alternative 3: Alternative 3 was given high benefit because of its positive effects on returning Delta hydrodynamics to a more "natural" condition, meaning the rivers and most channels maintain positive outflows at most times and places. Positive benefits for delta smelt may be high compared to other species because it is the only species to complete its entire life cycle in the estuary.

7. What degree of benefit and impact will the common programs provide?
The delta smelt team estimated that improvement would occur with the common programs. Much of the benefit predicted is due to the creation of additional shallow water habitat of several different types. The effect on delta smelt is uncertain. Much of this uncertainty stems from the scarcity of evidence of the effects of increasing such habitat. Delta smelt use such habitat for spawning but it seems to be of no special importance as rearing habitat. There is no evidence that spawning habitat is a limiting factor for the delta smelt population. While the habitat will also be favorable for predators, the increased spawning habitat and possible increases in Delta primary productivity and food supply were believed to be possible benefits and were assigned benefits even though this is an area of high uncertainty. Screening Delta diversions and improved Delta water quality are also expected to be beneficial.

5. What is the risk and chances of success of species recovery for each alternative?
For the delta smelt team recovery is defined in "The Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes" (Appendix 1). Alternative 1 is not a major change and probably has little influence on probability of recovery. Alternative 2 seems likely to negatively affect probability of recovery. Alternative 3 seems likely to improve the probability of recovery. All of these assessments are subject to the uncertainties already identified above.

4. SUMMARY MATRIX

The reader is strongly urged to read the detailed species reports in the Appendices for the details of the evaluations. In these reports each species teams developed rational and matrixes that scored the effects of the impact parameters on the life stages of each species by month for each alternative. In that process each team used an evaluation scoring scale referenced to a baseline that allowed that team to make relative evaluations between the alternatives for that species. Some set baseline at existing conditions with a score of "0" while others set baseline to pre-water project conditions. These scales were used by the teams to assist in addressing the primary and other issues. The teams did not try to achieve complete comparability in the baselines and scoring of the various species. For this summary report the team's adjusted the scores so that "0" , the baseline, in all cases is existing conditions and +7 is approaching full restoration. A minus score indicates that the alternative is worse than the existing conditions for the particular species. In general, the scores may be further subdivided as follows:

-3 to -1 = decreases in abundance likely (opposite effect of program goals)
0 = abundance is likely to be similar to existing conditions
+1 to +2 = small increases in abundance at best (unlikely to achieve program goals)
+3 to +5 = increase in abundance likely (may achieve program goals)
+6 to +7 = high likelihood that goals of restoration and recovery may be achieved.

Two types of general uncertainty were associated with the evaluation: 1)uncertainty associated with the existing conditions and causes of impacts on the species, and 2)uncertainty associated with the predicted benefits and impacts of the alternatives. Both types were integrated in the uncertainty scores in the tables below. For existing conditions the salmon team felt the causes of impacts on salmon species are well known and the uncertainty scores do not apply. The salmon team also recognized that considerable exists as to causes, but chose to reflect only uncertainty in predicted benefits and impacts in assigning uncertainty scores.

The integrated levels of uncertainty associated with the scores were assigned:

1 = Low uncertainty
2 = Moderate uncertainty
3 = High uncertainty

The following summary matrices show the score for improvement of the species, the uncertainty associated with the score, and a highlight of the benefit or impact for each alternative.

Salmon

Alternatives	**Sacramento River Salmon**	**San Joaquin River Salmon**
Existing Conditions	Score: 0 Uncertainty: NA - Interior-Delta survival is low. - Entrainment losses, suboptimal flow below Hood, and losses to Delta agricultural diversions.	Score: 0 Uncertainty: NA --Detriments associated with low interior-Delta survival, insufficient Vernalis flows, and high entrainment losses.
No Action	Score: 0 Uncertainty: 1 - Minor additional detriments did not warrant a change in summary score.	Score: 0 Uncertainty: 1 -Minor additional detriments did not warrant a change in summary score.
Common Programs	Score: +2 Uncertainty: 2 - Improvement would be driven by both increased shallow water habitat (shelter and reduced predation), and improved food supply. - Improved flows and reduction in agricultural-diversion losses also would contribute to improvement.	Score: +1 Uncertainty: 2 - Improvement would be driven by both increased shallow water habitat (shelter and reduced predation), and improved food supply. - Improved flows and reduction in agricultural-diversion losses also would contribute to improvement.
Alternative 1	Score: +2 Uncertainty: 2 - Benefits derived from Common Programs. - Insufficient change from Common Programs to warrant a change in summary score. - Small reduction in entrainment losses.	Score: +2 Uncertainty: 2 - Improved screens in the south Delta would provide a substantial benefit.
With new storage	Score: +1 Uncertainty: 2 - Reduced flow associated with storage considered sufficient to diminish Interior-Delta survival and increased entrainment losses reduce summary score for this option.	Score: +1 Uncertainty: 2 - Increased exports would contribute to increased entrainment and reduced interior-Delta survival. - Improved screens in the south Delta would provide a substantial benefit.
Alternative 2	Score: -1 Uncertainty: 3 - Interior-Delta survival would be improved. - Improvement would be outweighed by reduced flows below Hood, juvenile entrainment losses at the Hood screen, and the barrier to adult upstream migration (increased straying and delayed migration).	Score: +3 Uncertainty: 3 - Improved flow distribution in the interior Delta would increase survival. - Improved screens in the south Delta would provide a substantial benefit.
With new storage	Score: -2 Uncertainty: 3	Score: +2 Uncertainty: 3

Alternatives	**Sacramento River Salmon**	**San Joaquin River Salmon**
	- Reduced flow associated with storage considered sufficient to diminish Interior-Delta Survival and increased entrainment losses reduce summary score for this option.	- Similar adverse effects as in Alternative 1. - Improved screens in the south Delta would provide a substantial benefit.
Alternative 3	Score: +2 Uncertainty: 3 - Interior-Delta survival would be improved. - Improvement would be outweighed by reduced flows below Hood and juvenile entrainment losses at the Hood screen. - Tradeoff between beneficial and adverse effects yields the same summary score as for Common Programs.	Score: +4 Uncertainty: 2 - Anticipated ~80% reduction in south-Delta exports would reduce entrainment losses and further improve interior-Delta survival. - Improved screens in the south Delta would provide a substantial benefit.
With new storage	Score: +2 Uncertainty: 3 - Minor additional detriments did not warrant a change in summary score.	Score: +4 Uncertainty: 2 - Minor additional detriments did not warrant a change in summary score. - Improved screens in the south Delta would provide a substantial benefit.

Striped Bass

Alternatives	**Striped Bass**
Existing Conditions	Score: 0 Uncertainty: NA • Major entrainment of young life stages
No Action	Score: -1 Uncertainty: 3 • Major entrainment of young life stages
Common Programs	Score: +1 Uncertainty: 3 • Uncertain benefits of habitat improvements • Uncertain benefits/detriments of water quality improvements • In-Delta screening benefits juveniles
Alternative 1	Score: +1 Uncertainty: 3 • Increased entrainment of young life stages over existing conditions • Decreased mortality of entrained juveniles • QWEST not improved
Alternative 2	Score: 0 Uncertainty: 3 • Potential increased entrainment of eggs & larvae (north and south Delta) • Transport flows for eggs and larvae possibly decreased and mortality

Alternatives	**Striped Bass**
	increased • Decreased mortality of entrained juveniles • Improved QWEST • Adult passage problems and detrimental change in spawning location
Alternative 3	Score: +3 Uncertainty: 3 • Potential increased entrainment of eggs & larvae at Hood • Reduced entrainment of eggs, larvae and juveniles from the Delta • Transport flows for eggs and larvae possibly decreased and mortality increased unless strategic curtailments implemented. • Improved QWEST and Delta nursery habitat.

Delta Smelt

	Delta Smelt -Water Year Type	
Alternative	Wet	Dry
Existing Conditions[1]	Score: 0 Uncertainty: 2 - Baseline condition	Score: 0 Uncertainty: 2 - Baseline condition
No Action	Score: -1[2] Uncertainty: 3 - Negative effect because of increased diversion to meet increasing demand.	Score: -1 Uncertainty: 3 - Negative effect because of increased diversion to meet increasing demand.
Common Programs	Score: +2 Uncertainty: 3 - Positive benefit is hypothesized for increased shallow-water habitat. - Positive benefit is hypothesized for consolidation and screening of agricultural diversions.	Score: +2 Uncertainty: 3 - Positive benefit is hypothesized for increased shallow-water habitat. - Positive benefit is hypothesized for consolidation and screening of agricultural diversions.
Alternative 1	Score: +1 Uncertainty: 3 - The Common Programs provide the only positive benefit.	Score: +2 Uncertainty: 3 - The Common Programs provide the only positive benefit.
Alternative 2	Score: +1 Uncertainty: 3 - The Common Programs provide the only positive benefit. - The changes in conveyance and resulting hydrodynamics will negatively effect all life stages.	Score: +1 Uncertainty: 3 - The Common Programs provide the only positive benefit. - The changes in conveyance and resulting hydrodynamics will negatively effect all life stages.
Alternative 3	Score: +4 Uncertainty: 3 - Positive benefits of Common Programs. - Reduced entrainment. - Improved hydrodynamics.	Score: +5 Uncertainty: 3 - Positive benefits of Common Programs. - Reduced entrainment. - Improved hydrodynamics.

[1] Existing conditions for wet and dry conditions are not the same. Existing conditions for dry years are worse than

for wet conditions. Do not compare across the columns.

[2] The negative effect for both year types is actually less than a full unit. The -1 simply implies a slight negative effect, in this case only.

DIVERSION EFFECTS ON FISH

APPENDIX A

CALFED ALTERNATIVE EVALUATION FOR CENTRAL VALLEY SALMON SURVIVAL WITHIN THE DELTA

DIVERSION EFFECTS ON FISH

CALFED ALTERNATIVE EVALUATION FOR
CENTRAL VALLEY SALMON SURVIVAL WITHIN THE DELTA
NARRATIVE

Draft - June 23, 1998

In this report, we describe an analysis of diversion effects on Central Valley chinook salmon within the Delta. Our assignment was to evaluate variations in the survival of chinook salmon within the Delta for each of several scenarios being considered in the CALFED Program. The scenarios are No Action, Common Programs and Alternatives 1, 2, and 3, and are evaluated in relation to Existing Conditions. Our evaluation is based on one operation study for each scenario. Because variations in operations could result in considerable differences in effects on chinook salmon within the Delta, our analysis provides only a first approximation of potential differences among scenarios.

We evaluated the effects of CALFED water storage and conveyance alternatives on chinook lifestages in the Delta; we did not evaluate overall effects on chinook population dynamics. An analysis of survival throughout the entire Sacramento and San Joaquin basins, in the Delta and Bay, and in the ocean would be necessary to assess the effects of the CALFED program on overall chinook population dynamics. Evaluation of effects on survival upstream from the Delta would be particularly important for the CALFED Ecosystem Restoration and Water Quality Programs. Evaluation of effects of ocean conditions and commercial and recreational harvests would be important to provide an appropriate perspective on impacts in the ocean. Although our within-Delta analysis is not sufficient to evaluate the effects of the entire CALFED program, it is sufficient to describe the full effects of the alternative ways of transferring water across the Delta being considered in the CALFED Programmatic Environmental Impact Statement.

We prepared separate analyses for chinook salmon from the Sacramento and San Joaquin systems, because of their different uses of the estuary. From the San Joaquin system, only one race, fall run, is involved. From the Sacramento system, four races are involved, each juvenile lifestage using the estuary to a different extent and during a distinctive time period, collectively using the estuary in every month except July. (In August, estuary use is limited to adults immigrating upstream, and the subcommittee identified no adverse effects.)

Two of the races, the Sacramento winter and spring runs, are receiving protection under endangered species laws and thus require special consideration in making management decisions. At this stage, the subcommittee's analysis integrates effects over all runs, without separately identifying effects on the listed runs.

We first analyzed the effects (by month) of parameters expected to influence salmon survival in the Delta. We used the results of this analysis to answer a series of questions posed by CALFED. This report includes both a description of our analysis and answers to CALFED's questions.

The subcommittee is co-chaired by Patricia Brandes, U. S. Fish and Wildlife Service and Sheila Greene, Department of Water Resources. Other biologists participating fully throughout the analysis were Serge Birk, Central Valley Project Water Association, Pete Chadwick, Department of Fish and Game, Karl Halupka, U. S. National Marine Fisheries Service, Jim Starr, Department of Fish and Game, and Jim White, Department of Fish and Game.

METHODS

We developed a matrix for each CALFED scenario. All matrices consist of rows for each parameter expected to affect salmon survival in the Delta, and columns for each month and the sum of all months (Appendix A, pages A15-A20). We assign an integer value to each matrix cell reflecting the relative magnitude of adverse or beneficial effects of each parameter on the population of juvenile chinook in the Delta in each month. We scored Existing Conditions first, and then sequentially No Action, Common Programs, and Alternatives 1, 2, and 3. We completed two analyses for Alternatives 1, 2, and 3; for the alternatives with no additional storage and for the alternative with the maximum amount of storage being considered by CALFED. Initially, under Existing Conditions, integer values ranged from -3 to +3, but for matrices that were scored subsequent to Existing Conditions, values ranged outside -3 to +3 to maintain a consistent assessment of magnitude of effect relative to Existing Conditions.

The primary goal of scoring the Existing Conditions matrix is to obtain a set of consensus values that accurately describe present conditions. These values subsequently serve as a baseline for comparison with other scenarios. We assign Existing Conditions values that we consider reasonable in relation to limiting factors, without making any attempt to relate values to some specific set of historical conditions. We do not attempt to define “recovery,” “restoration,” or any other potential CALFED goals.

We consider both the magnitude of effect of each parameter and the proportion of the population present in the Delta in determining the value for each cell in the matrix. For example, a parameter causing a small change on a large proportion of the population could have the same population effect as a parameter causing a large change on a small proportion of the population, and thus could receive the same value.

We used best professional judgement to determine the degree to which each parameter affects salmon survival. We considered empirical relationships between parameters and survival, when relationships were available. Our evaluations were based on qualitative assessments of the degree to which water operations, water management facilities, and biological factors affect chinook salmon in the Delta.

For the Sacramento system, we consider each of the four races of chinook and their occurrence in the Delta as fry, smolts and yearlings. We integrate effects over all life stages of all races, including returning adults immigrating through the Delta, to determine values for each matrix cell.

To clarify and summarize the results in the matrix analysis, we created composite parameters (Tables 2 and 3; Appendix A, pages A15-A20). One composite parameter is Entrainment Losses. It is an estimate of losses occurring immediately in the vicinity of export diversions, either at the SWP and CVP south Delta diversions or at a new Hood facility. The overall estimate of Entrainment Losses is based primarily on the Percent Exposed parameter. If the sum of the other three entrainment related parameters (Screen efficiency/Predation, Trucking/

Handling and Clifton Court Forebay Loss) exceeds 3, we adjust the Percent Exposed parameter by -1 to reflect increase severity of Entrainment Losses.

Another composite parameter is Interior-Delta Survival. It is the survival of juvenile salmon diverted from the mainstem Sacramento River into the Mokelumne and San Joaquin portions of the Delta, and juvenile salmon emigrating through the San Joaquin portions of the Delta, exclusive of Entrainment Losses. Interior-Delta Survival is the sum of Flow Distribution, Delta Cross Channel, Predation, Temperature, and Salinity. Flow Distribution is based on flows in Old and Middle Rivers and San Joaquin River downstream of the Mokelumne River in the DSMII operation studies. Old and Middle Rivers connect the lower San Joaquin River to the south Delta export facilities.

We make separate estimates for the five component parameters under Interior-Delta Survival to reflect some knowledge of the independent effects of individual parameters, but are more certain of the overall estimate of Interior-Delta Survival than the values of the individual parameters. Our increased certainty is based on extensive smolt release and recapture experiments using hatchery smolts. Paired experiments result in an estimate of differential survival of smolts released simultaneously in the mainstem Sacramento River and in the Interior Delta, and subsequently recaptured downstream of the Delta. We recognize the survival of hatchery smolts probably does not reflect the survival of wild smolts precisely. Although the experiments were not designed to identify the sources of decreased survival, we assumed the sources to be the five parameters under Interior-Delta Survival. The results of the paired experiments were that survival of smolts diverted into the interior Delta was one third or less of the survival of smolts remaining in the mainstem Sacramento River (Table 1). The small proportion of chinook salvaged at the CVP and SWP south Delta exports indicates most of the decrease in survival is due to Interior-Delta Survival rather than Entrainment Losses.

Among the component parameters under Interior-Delta Survival, a majority of the subcommittee considers the Flow Distribution parameter to be a surrogate for effects associated with flow and olfactory cues, which are believed to be related to survival indirectly through mechanisms such as influencing the duration of emigration. Members of the committee all agree that the Flow Distribution effects are greatest near the south Delta export facilities when pumping rates are greatest. There is not consensus as to how widespread the effects are, and in particular whether they extend to the San Joaquin River in the central Delta where tidal flows far exceed net freshwater flows. Also, a minority of the subcommittee recommended it would be more appropriate to distribute some of the magnitude of effects represented in the Flow Distribution parameter among the other component parameters, such as, predation, temperature and salinity.

We based our evaluations on a single operation study for each scenario. The specific CALFED operation studies used for each scenario are: Existing Conditions - 558, No Action - 516, Alternative 1 without storage - 518, Alternative 1 with storage - 609, Alternative 2 without storage - 528, Alternative 2 with storage - 532a, Alternative 3 without storage - 595, and Alternative 3 with storage - 567. Flow changes associated with the Common Programs were evaluated by comparing flows below Hood and at Rio Vista in study 518 to flows in studies 516 and 518, and from tables in Appendix E of the 19 May 1998, draft modeling studies. The operation studies consist of flows at selected locations in the Delta, computed on a monthly timestep, then averaged over all years from 1922 to 1994, dry and critical years, and other subsets. We recognized the pitfalls associated with using average values, but we did not have time to explore fully, or to consider scoring, the full range of annual variability.

One of the parameters included in the matrices is Toxics. Acute and chronic toxic effects have been identified in the Delta, but results of standard toxicity bioassays have not been related directly to salmon in ways that the subcommittee felt competent to judge. Such effects would be expected to change due to the CALFED Water Quality Program, but that program is not yet described with sufficient specificity to judge how it might affect salmon. Water quality differences may also occur among alternatives due to differences in dilution in different areas of the Delta, or due to changes in the toxic constituents delivered to the Delta associated with changes in proportional flow from the Sacramento and San Joaquin rivers. The subcommittee did not feel competent to offer judgements on any of these aspects of toxicity.

In the matrices, the sum of all months is the overall annual effect of each parameter. Upon examining annual estimates for some parameters, or groups of parameters, in the Sacramento matrices, the subcommittee concluded that some parameters were not weighted properly in relation to other parameters. In such cases, the subcommittee divided or multiplied the annual estimate by a constant to provide the proper relationship among parameters or groups of parameters. Only the annual estimates were weighted in that fashion, so the reader needs to use caution in reaching conclusions based on comparing monthly values. For the San Joaquin system, weighting among parameters was incorporated directly as cells were assigned monthly values.

Two weighting factors were applied to the results of Sacramento River evaluations. When we compared the annual estimates for Entrainment Losses (-20) to the annual estimate for Interior-Delta Survival (-30), we concluded that this reflects an over weighting of Entrainment Losses (Table 2). Dividing Entrainment Losses by 4 brought them roughly into balance with empirical evidence on the relative effects on survival of these two parameters. Entrainment Losses in all Sacramento matrices were weighted in this fashion.

We identified another weighting disparity between relative magnitudes of Interior-Delta Survival and Flow below Hood in the Sacramento River. We concluded that Flow Below Hood should be multiplied by 2 to make the annual estimates for that parameter similar in range to the annual estimates for Interior-Delta Survival. Our justification for weighting survival in the Sacramento River and in the interior Delta nearly the same is that about four times as many salmon remain in the Sacramento River with the Delta Cross Channel gates closed as are diverted into the Delta, but the survival rate of juvenile salmon diverted into the interior Delta is reduced to one third or less of the rate for smolts that remain in the Sacramento River (Table 1).

RESULTS

Chinook Salmon From The Sacramento System

Existing Conditions

In summary, we determined that Existing Conditions have negative impacts primarily due to decreased Interior-Delta Survival and Entrainment Losses, both being substantial in all months except July and August.

No Action

We concluded that the only substantial difference in comparison to Existing Conditions was due to increases in exports of about 10% annually. The result of increased exports were shown as small increases in Entrainment Losses in January and February and small decreases in Interior-Delta Survival in December and January (Table 2).

Common Programs

The Common Programs that we judged would have some effect on survival of Sacramento salmon were the flow augmentations, wetland and riparian restoration (which translated into decreased predation, more extensive shallow water habitat, and enhanced food supply in the analysis), and agricultural diversion screening components of the Ecosystem Restoration Program (Table 2). We believe the effect of a flow augmentation of about 5% in March and May would be marginal in the Delta in relation to the other parameters' effects, therefore we increased the value of Flow Below Hood only during May in the matrix.

The relative effects of wetland and riparian restoration programs were difficult to judge. Where these habitats are available, they are used by juvenile salmon as rearing habitat, and provide both terrestrial and aquatic foods for both rearing and emigrating juvenile salmon. These habitats also would be likely to increase the abundance of predators, but most biologists agree that some net benefits would occur for salmon. We are not aware of experimental evidence that estimates the magnitude of such benefits. In the Ecosystem Restoration Program, CALFED proposes moderate increases in existing habitat in the Delta. It is not clear, however, how restored habitat will be distributed. Benefits would likely be greater than those we estimated if the habitat were concentrated in migration corridors for salmon. We concluded that restored habitat would provide modest rearing benefits, primarily from December through March, food supply benefits from December through May, and reduced in-Delta predation from March through May.

We estimated that screens on Delta agricultural diversions would reduce existing impacts in April, May, and June.

Alternative 1

We concluded that the primary changes in relation to Existing Conditions, beyond those attributable to the Common Programs, would be small decreases in Entrainment Losses (Table 2). The new fish screens at the intake to Clifton Court Forebay for both the CVP and SWP would improve screen efficiencies and eliminate predation losses now occurring in Clifton Court Forebay. Under Alternative 1 with storage, this improvement would be offset, to some degree, by exposure of a greater number of salmon to the screens from December through March, and decreased Interior-Delta Survival from October through March, due to increased exports.

Alternative 2

Several substantial changes would occur under Alternative 2 (Table 2). First, Entrainment Losses would increase. This would result from the combination of exposure to a new diversion at Hood and continued exposure to diversions in the south Delta. The fraction exposed to a diversion at Hood would be substantially greater than the fraction exposed now to the diversions in the south delta. The fraction exposed in the south Delta would not change much, as a result of a fairly complicated set of interactions. A larger fraction of the salmon would be diverted into the interior Delta, due to the lower flows below Hood intake increasing both the density of salmon in the Sacramento River and the proportion of flow diverted through Georgiana Slough into the interior Delta. The increase would be more or less offset by more favorable flows in the interior Delta causing a smaller fraction of the salmon to go to the south Delta diversion and a larger fraction to migrate west towards the ocean.

A second adverse effect would be the Flow below Hood in the Sacramento River. The subcommittee expects this would decrease survival from September through June, with the greatest reductions occurring when the greatest fraction of flow is being diverted at Hood and when the flows are the lowest.

A third adverse effect would be the need to pass adult salmon migrating upstream through the San Joaquin-Mokelumne route to the Sacramento River. These fish would have to pass the Hood fish screen and pumping plant. While a bypass facility would be built, we determined it would probably impose new impacts on the adult population.

A beneficial effect under Alternative 2 would be improved Interior-Delta Survival for salmon smolts diverted through Georgiana Slough, due to more favorable flow distribution in the San Joaquin River and the avoidance of any need to open the Delta Cross Channel gates.

Alternative 3

This Alternative would not have the adult salmon passage problems at the Hood fish screens and pumping plant as would occur with Alternative 2. Otherwise the changes would parallel those for Alternative 2.

Entrainment Losses would increase (Table 2) for the same reasons described for Alternative 2, but the increases would be less than in Alternative 2, because exports from the south Delta would be reduced by about 80% and water diverted into Georgiana Slough would be distributed more favorably.

Survival in the Sacramento River below Hood would be reduced by essentially the same amount as for Alternative 2.

Interior-Delta survival would be even better than for Alternative 2, due to better flow distribution in the San Joaquin River.

Chinook Salmon from the San Joaquin System

Existing Conditions

Salmon from the San Joaquin system use the Delta over a smaller portion of the year than salmon from the Sacramento system (Appendix 2). Adults migrate upstream in the fall, some fry move downstream in January and February to rear in the Delta, and most of the juveniles emigrate downstream as smolts from March through June.

Entrainment Losses in the south Delta are controlled by the same parameters as those that control Entrainment Losses for salmon from the Sacramento, but the proportion of the population exposed to the screens is much greater because the screens are directly on their migratory pathway.

Interior-Delta Survival is also controlled by similar parameters, except that opening the Delta Cross Channel gates does not have a direct impact, but a barrier at the head of Old River reduces impacts.

Flows at Vernalis replace flows below Hood as a parameter. Flows at Vernalis have been shown to be correlated to escapement two and a half years later (Kjelson, Brandes, 1989). In addition, the survival of CWT smolts released in the south Delta is positively correlated to flow at Stockton and Vernalis (IEP Newsletter, Winter 1998).

Flows during the fall are inadequate for adult attraction and upstream passage. Entrainment Losses, Flows at Vernalis and Interior-Delta Survival are all of concern from January through June. Measures prescribed in the VAMP agreement and the head of Old River barrier partially mitigate adverse conditions in April and May.

No Action

Conditions are similar to Existing Conditions, except for slightly greater Entrainment Losses and poorer Flow Distribution in January and February (Table 3).

Common Programs

As for the Sacramento system, screening Agricultural Diversions and creating wetland and riparian habitat as part of the Ecosystem Restoration Program provide benefits of the same magnitude, and subject to the same caveats as those described for the Sacramento system (Table 3). In addition, flow augmentation provided as part of the Ecosystem Restoration Program are expected to improve conditions in May.

Alternative 1

New screens at the intake to Clifton Court Forebay would substantially reduce Entrainment Losses particularly for Alternative 1 without storage (Table 3). For this alternative with storage, Flow Distribution would become somewhat worse in January through March.

Alternative 2

In comparison to Alternative 1, Interior-Delta Survival would improve due to improved Flow Distribution downstream from the mouth of the Mokelumne River (Table 3). Otherwise conditions would be similar to those for Alternative 1.

Alternative 3

Reductions in diversions from the south Delta by about 80% would substantially reduce Entrainment Losses and improve Interior-Delta Survival due to Flow Distribution throughout the San Joaquin Delta being even more favorable than in Alternative 2 (Table 3). These changes would improve conditions both for adults migrating downstream and for young rearing in the Delta and migrating downstream.

5. Which population or life stages are most sensitive to diversion effects under no action and Alternatives 1, 2, and 3? When and where are they most affected?

Under the No Action Alternative, the San Joaquin basin chinook would be more vulnerable to effects of diversions from the south Delta than Sacramento chinook. All San Joaquin chinook migrate through the south Delta, where they are highly susceptible to direct entrainment, predation in Clifton Court Forebay, and reduced survival associated with unfavorable flow distribution in the southern and a much smaller proportion of the population of Sacramento chinook are affected by diversions from the south Delta.

Under Alternative 1, San Joaquin and Sacramento chinook Entrainment Losses would be reduced by elimination of Clifton Court Forebay predation, although the altered flow distribution still would affect San Joaquin and Sacramento chinook through prolonged exposure to a variety of mortality sources in the Delta.

Under Alternative 2, the entire population of Sacramento chinook would emigrate past Hood and thus would be exposed to a screened diversion at Hood and to reductions in flow in the Sacramento River downstream from Hood. The San Joaquin and Sacramento chinook that would emigrate through the interior Delta would still be affected by changes in interior-Delta hydrodynamics, although to a lesser degree than in Alternative 1, because of the increased frequency of net downstream flows below the mouth of the Mokelumne River. An effect unique to Alternative 2 would be that adult salmon returning to the Sacramento basin that have been attracted to the Mokelumne River portion of the Delta would be affected adversely due to delays in migration and other impacts at whatever fish passage facility would be constructed at Hood to return these salmon to the Sacramento River.

Under Alternative 3, San Joaquin chinook would benefit from restored flow distribution patterns in the south and central Delta, reduced pumping, and improved screens in the south Delta. Sacramento chinook would still be adversely affected by reduced flows in the Sacramento River. The effect of altered flow distribution on the survival of salmon that enter the interior Delta would be better than for Alternatives 1 or 2.

Juvenile chinook are considered to be at greatest risk to diversion effects due to their need to find their way through the Delta to the ocean. Yearlings and smolts are considered more subject to diversion effects than rearing fry, because they are actively migrating. Fry rearing in the Delta are important to salmon production, especially in wet years, and their survival depends on conditions over a several month period prior to their migrating to the ocean as smolts. During their emigration, they are presumably just as subject to diversion effects as smolts entering the Delta after rearing in upstream areas.

2. Can diversion effects in the South Delta be offset by habitat improvements and other common program actions?

Modest benefits for juvenile chinook were estimated due to enhanced food supply and physiological condition, reduced toxicity, reduced entrainment in small diversions, and more extensive rearing and escape habitat associated with the ERP element of the Common Programs. Considerable uncertainty surrounds how the ERP will be implemented and thus the magnitude of associated benefits. The presumed benefit for salmon from improvement or type conversion of existing habitat is proportionally modest. If the ERP emphasized improving habitat along migration corridors for salmon, benefits would be greater than estimated in this analysis. Increased flows in March and May in the Sacramento River and in May in the San Joaquin River provided by the ERP would provide a minor improvement in chinook survival in the Delta, in addition to the benefits that would be expected upstream of the Delta. Overall, we concluded that the common programs would not provide enough benefits in the Delta to offset fully diversion effects.

The subcommittee did not attempt to estimate benefits to salmon from the Water Quality Program.

3. To what extent can Alternatives 1, 2 and 3 offset diversion effects as presently configured?

    Our answer to question 1 answers this question as well.

4. To what extent can diversion effects be offset by modifications to the Alternatives or by operational changes?

    The subcommittee has not addressed this question.

5. What is the risk and chances of success of species recovery for each alternative?

The probability for recovery depends on conditions throughout the life history of salmon. Because the subcommittee considered only needs of young and adults in the Delta, the following answers only partially address the question of recovery.

No Action- The No Action scenario continues to rely on closure of the Delta Cross Channel gates from November through June to improve the survival of salmon migrating down the Sacramento River. This has a high risk of conflict with water supply operations during low flow periods.

The ongoing efforts of the Ops Group to improve salmon survival under Existing Conditions in the face of limited operational flexibility indicates that very little “recovery” potential would exist under the No Action scenario.

Common Programs- See the answer to Question 2.

Alternative 1- As with the No Action scenario, reliance on closure of the Delta Cross Channel gates would continue.

Experience with fish screen operations in the south Delta indicate a high probability that the benefits expected from improved fish screens would be achieved. Such benefits are limited by the need for continued handling and trucking, but experimental evidence indicates this is less of a risk for salmon than for many other species.

Alternative 1 includes measures such as the Water Use Efficiency and Water Transfer programs, which would somewhat increase flexibility in water supply operations. Thus Alternative 1 offers some potential for shifting diversions to times less detrimental to salmon, but such shifts would be likely to increase impacts on other species, would sometimes interfere with water supply benefits, and probably would not be sufficient to cause major improvements in salmon production.

Overall, Alternative 1 is not likely to result in significant increases in survival for salmon from the Sacramento system.

For the San Joaquin, Alternative 1 would increase salmon survival somewhat, due to the improved structure and location of the fish screens.

Alternative 2- Risks for new screens in the south Delta are the same as described for Alternative 1. Several new risks for salmon from the Sacramento system are inherent in Alternative 2 associated with the diversion at Hood. One is the fish screens themselves. Advances in fish screen design provide good evidence that a successful screen can be built, but all large fish screens have inherent risks. Even the best screen would increase the risk for salmon from the Sacramento system, due to the greater exposure of the population to the screen. Also, the screen and the pumping plant that would accompany it would pose a new risk for adults migrating upstream. Finally, the diversion would reduce flows in the Sacramento River below Hood. The subcommittee recognized considerable uncertainty in the consequences of that reduction, based both on questions about evidence of the effects on survival and about the magnitude of flow reductions that would occur over the range of operating conditions. The subcommittee, however, believes that Alternative 2 would pose risks for salmon from the Sacramento system greater than any other alternative. For salmon from the San Joaquin, Alternative 2 would be intermediate between Alternatives 1 and 3.

Alternative 3- San Joaquin basin chinook have the greatest potential to benefit from Alternative 3, but the improvement may not ensure "recovery". Flows at Vernalis are strongly correlated to population levels of San Joaquin salmon, and although the Alternatives would improve San Joaquin flows as a result of ERP flows and VAMP, the improvements in survival are expected to be small.

The benefits that are most certain are the reduction in entrainment losses associated with the large reduction in diversions from the south Delta. Those benefits would be greatest for San Joaquin stocks and for those smolts diverted into the central Delta from the Sacramento River via Georgiana Slough.

Alternative 3 would not have the risk for upstream migrants that Alternative 2 would have because there are no attraction flows for adults in the central Delta. Other risks of the Hood diversion would be essentially the same as those described for Alternative 2.

6. What increment of protection or improvement for fish species will be provided by other programs such as the CVPIA, biological opinions?

The increment of improvement for the various programs is difficult to quantify, but if most of the actions contained within the Anadromous Fish Restoration Plan are implemented, substantial improvement should be achieved. The CALFED program, as it is proposed, would include restoration elements not included in CVPIA and the Winter Run and Delta Smelt

Biological Opinions.

7. What degree of benefit and impact will the common programs provide?

We estimated that improvement would occur with the common programs. Much of the benefit predicted is due to the creation of additional shallow water habitat of several different types. The effect on salmon is uncertain, largely due to the scarcity of evidence regarding the ecological tradeoffs associated with increasing restored habitat area in an aquatic ecosystem dominated by introduced species. Salmon, particularly presmolts, are likely to use restored habitat. Although the habitat will also be favorable for predators, the increased cover and food supply will increase salmon survival in the opinion of most salmon biologists. Screening Delta diversions and improved Delta water quality are also expected to be beneficial.

8. What are the direct and indirect effects on chinook populations resulting from each Alternative and what is the expected response of the populations to these effects?

The Results section and summary tables included in this report address this question. However, the subcommittee is concerned that some readers may focus on the summarized information without appreciating the imprecision and uncertainties involved. The numbers in the summary tables should be interpreted carefully and are most appropriately used to support broad generalizations such as those offered after the summaries. Imprecision and uncertainty are involved throughout, and the subcommittee is particularly concerned with Flow Below Hood and Interior-Delta Survival. We did not have adequate time to explore and cite the available evidence to the degree that we would have liked, and even if we had, considerable uncertainty would remain as to both the magnitude of effects and the controlling mechanisms.

The annual sums are useful for gross comparisons among scenarios, but the monthly evaluations are essential for more fully understanding the scenarios and formulating alternative operations.

A summary for the Sacramento system (Table 1) is that compared to Existing Conditions the Common Programs would provide a substantial benefit, but some negative consequences would persist. With Alternatives 1 and 3, approximately the same net magnitude of consequences would persist as with the Common Programs, but for quite different reasons. For Alternative 1 there would be little change from the Common Programs for any category of parameters, and for Alternative 3, our estimate of improvements in Interior-Delta Survival would be offset by detriments from flow reductions below Hood. For both Alternatives 2 and 3, the consequences of flow reductions below Hood would vary considerably depending on the magnitude of flow. In high flow periods, effects might be inconsequential, but in low flow periods, survival would probably be less than the approximation of the overall average included in the summary.

A summary for the San Joaquin system (Table 2) is that compared to Existing Conditions the Common Programs would provide benefits similar to those provided for the Sacramento system. As in the Sacramento system, Alternative 1 would provide little change from the Common Programs. For Alternatives 2 and 3 the consequences would be quite different than for the Sacramento system. Alternative 3 would clearly be superior, and Alternative 2 would provide intermediate benefits.

Table 1
Survival indices to Chipps Island for coded wire tagged fall run smolts and late-fall run yearlings released at Ryde and in Georgiana Slough between 1992 and 1996.

Fall run

Date	Ryde	Georgiana Slough	Ratio (GS/R)
4/6/92	1.36	0.42	0.30
4/14/92	2.14	0.73	0.34
4/27/92	1.67	0.20	0.12
4/14/93	0.41	0.13	0.31
5/10/93	0.86	0.29	0.33
4/12/94	0.20	0.06	0.30
4/25/94	0.18	0.11	0.61
		Mean =	0.33

Late fall

Date	Ryde	Georgiana Slough	Ratio (GS/R)
12/2/93	1.91	0.28	0.14
12/5/94	0.57	0.16	0.28
1/4/95	0.33	0.12	0.36
1/10/96	0.66	0.17	0.25
1/13/98*	0.90	0.24	0.27
12/4/97*	0.70	0.03	0.04
		Mean =	0.22

* Preliminary data

Table 2
Summary of matrices evaluating the effects in the Delta on chinook salmon from the Sacramento River basin. Alternatives 1, 2, and 3 were evaluated without any new storage and with maximum new storage contemplated by CALFED (results are presented: without/with).

Effects	Existing	No Action	Common	Alt. 1	Alt. 2	Alt. 3
Entrainment Losses	-5	-6	-6	-4 / -5	-7 / -8	-6 / -7
Flow below Hood	-6	-6	-4	-4	-28	-28
Interior-Delta Survival	-30	-32	-25	-25 / -31	-7 / -12	0
Shallow water habitat, food supply & ag diversion screens	-3	-3	+10	+10	+10	+10
Upstream migration of adult salmon	0	0	0	0	-19	0
Total	-44	-47	-25	-23 / -30	-51 / -57	-24 / -25
Change from existing conditions		-3	+19	+21 /+14	-7 / -13	+20 /+19
Change from Common Programs				+2 / -5	-26 / -32	+1 / 0

Table 3
Summary of matrices evaluating the effects in the Delta on chinook salmon from the San Joaquin River basin. Alternatives 1, 2, and 3 were evaluated without any new storage and with maximum new storage contemplated by CALFED (results are presented: without/with).

Effects	Existing	No Action	Common	Alt. 1	Alt. 2	Alt. 3
Entrainment Losses	-12	-13	-13	-7 / -10	-7 / -10	-2 / -2
Vernalis flow	-18	-18	-17	-17	-17	-17
Interior-Delta Survival	-23	-25	-19	-19 / -22	-2 / -5	+14 /+14
Shallow water habitat, food supply & ag diversion screens	-3	-3	+8	+8	+8	+8
Total	-56	-59	-41	-35 / -41	-18 / -24	+3 / +3
Change from existing conditions		-3	+15	+21 /+15	+38 /+32	+59 /+59
Change from Common Programs				+6 / 0	+23 /+17	+44 /+44

DIVERSION EFFECTS ON FISH

APPENDIX B

CALFED ALTERNATIVE EVALUATION FOR STRIPED BASS

DIVERSION EFFECTS ON FISH

CALFED ALTERNATIVE EVALUATION FOR STRIPED BASS
NARRATIVE

Draft - June 23, 1998

Introduction-Evaluation Team and Process:

The CALFED task of evaluating diversion effects on fish was [illegible] species subcommittees. The striped bass subgroup met twice and evaluated th[illegible] impacts of the alternatives based on information provided in the CALFED Phase II rep[illegible]nt operation studies.

The striped bass evaluation is based on a review by biologist[illegible]with kn[illegible]the striped bass population and historic relationships of egg and larva distribution an[illegible] young-of-the-year abundance, and adults in relation to estuarine [illegible]itions and hist[illegible]. Participants on the work team are Stephani Spaar (Departme[illegible]Resources), [illegible] Kohlhorst, Lee Miller, Kevan Urquhart, and Don Stevens [illegible] Fish and Ga[illegible]). Elise Holland (Bay Institute) was a member of our team but [illegible]s unable [illegible] meeti[illegible]s when the matrices of diversion effects were developed. Th[illegible] report is t[illegible] re[illegible]actions of this group.

Methods:

We completed matrices (pages B[illegible]17) for: ex[illegible]ng conditi[illegible]s, no action conditions (projection of increased demand on exis[illegible] facilities)[illegible]mon pr[illegible]ams, diversion alternatives 1, 2, and 3 and full restoration. Th[illegible]at[illegible]es were us[illegible]d checklist to assure our consideration[illegible]he relevant di[illegible]ues. We a[illegible]e of -5 to +5 to express the relative im[illegible]fects iden[illegible]matrix as ma[illegible]omponents that would affect striped bass in rel[illegible] diversion[illegible]ns were based on qualitative assessments of the degree to wh[illegible]s affect the[illegible]. We used two CALFED operations draft studies to evalua[illegible]erations (C[illegible]8). Entrainment impacts included predation in Clifton Court, los[illegible]to screen i[illegible]es, handling and release site mortality. However, these [illegible] scored [illegible]ere included in our evaluation. After the matrix scoring was [illegible]pleted, w[illegible]elative weight factors to each component of the matrix. We also li[illegible]ted the fall-win[illegible] combinations of months which became self-weighting in the p[illegible]cess since striped ba[illegible]ese periods generally tend to be less vulnerable to diver[illegible]ns.

Existing conditions a[illegible]the diversions as operated currently with the 1995 Water Quality C[illegible]ol Plan Delta Standard[illegible]in effect. An evaluation of full restoration conditions relative to [illegible]sting conditions an[illegible]lternative choices was made to assess the extent to which the striped [illegible]ulation would [illegible] restored with the proposed alternatives. All matrices were completed [illegible]ALFE[illegible]erations studies provided. This was a judgmental process with no striped b[illegible] analysis, or quantitative assessments because time constraints did not permit mo[illegible]any cases we cannot be certain how the population might respond to the new conditions being proposed.

Results

The following questions were evaluated.

1. Which life stages are most sensitive to diversion effects under no action and alternatives 1, 2, and 3? When and where are they most affected?

Existing Conditions

Diversions in the Delta have had a major impact on the striped [illegible] population [illegible] nursery area historically has been the Delta and Suisun Bay. (Chadwi[illegible] et al. 1977, [illegible]evens, et al. 1985, IESP 1987, Department of Fish and Game 1992). The decl[illegible] in both th[illegible] young of the year (YOY) measure of abundance (38 mm index) and adults have be[illegible] the effects of entrainment losses in the Delta. Diversion effects on striped bass and [illegible] were empirically demonstrated in 1977, a severe drought year, when flows were so low th[illegible]mping was minimal or ceased for much of the year because of water quality probl[illegible] freshwater inflow. As a result there was an accumulation of striped b[illegible]s in the [illegible] evident by the large number of striped bass salvaged when export pumping did r[illegible] Delta inflow increased in December. Such accumulations of fis[illegible] Delta were [illegible] in either 1976 or 1978, years when export pumping was not cu[illegible] summer (Ta[illegible]

Table 1. Export pumping rates and delta smelt and stri[illegible] bass sa[illegible] State W[illegible]ter Project (SWP) in 1976, 1977 [illegible] 1978. Da[illegible] pr[illegible]FED by H. K.Chadwick 1998.

	1976-1977			1977-1[illegible]8			1978-1979		
	SWP Pumping-00's cfs	Delta smelt 000's	striped Bass 0[illegible]'s	[illegible]umping [illegible]00's cfs	D[illegible] [illegible]lt	Striped Bass [illegible]	SWP Pumping -00's cfs	Delta Smelt 000's	Striped Bass 000's
May	[illegible]	102	[illegible]	11	[illegible]	[illegible]	9	4	1
June	[illegible]	277	[illegible]	[illegible]	3	53	33	36	633
July	3	[illegible]	639	[illegible]	43	367	34	1	1,115
Aug	21	[illegible]	156	[illegible]	6	12	40	2	307
Sept	[illegible]	1	[illegible]	2	18	1	35	0	18
Oct	14	0	[illegible]	1	3	0	20	0	173
N[illegible]	16	0	32	9	0	22	22	0	171
[illegible]	10	0	20	22	55	63	27	1	172
[illegible]	33	[illegible]	58	60	134	590	13	0	34
[illegible]	[illegible]	2	10	61	54	306	16	1	8

[illegible] analyses also support these findings. Recently Kimmerer, et al. manuscript, sugg[illegible] density-dependent survival may moderate the effects of flows and diversions on year class strength. While relative year class strength often changes between YOY and recruitment at age 3, density-dependent survival does not fully compensate for lower numbers of

YOY striped bass. The adult population was 1.8 million in early 1970's and has declined to about 0.5 to 0.7 million in the 1990's. This decline in adults is consistent with the general declines in egg abundance and the 38-mm index of young abundance. Compensation is insufficient to offset the decline in egg production which has ranged from 319 billion in 19[illegible], to 31 billion, in 1996. Hence, there has been an order of magnitude decline in egg productio[illegible] versus only a 2/3 decline in the number of adults. Kimmerer, et al., manuscr[illegible]t, states “[illegible] median losses to pumping were estimated at 33 percent, a substantial frac[illegible] the tota[illegible] mortality and losses were often much higher.”

The Oakridge National Laboratory Individual Based Model res[illegible]s (draft report [illegible] in preparation by Kenny Rose) indicate that diversions and food supply [illegible]iables toget[illegible] account for the decline in striped bass. However, if only diversions were set a[illegible]-bass de[illegible]ne levels in the model, the population would recover to a stable population of abo[illegible]mill[illegible]n adults which, though not the historic measured high of 1.8 million, is evidence of th[illegible]e of diversions in driving the striped bass population decline. Food by itself in the mod[illegible]ly a decline to 1.5 million adults but when both food and diversions are included th[illegible]op[illegible]clined to 0.5 million. These model runs were made with density-dependence a[illegible]ounted [illegible]odel.

Apparent adult mortality has also increased in recent years and increased [illegible] migrations which result in straying to other estuaries and possib[illegible]ermittent retu[illegible] estuary to spawn has been suggested as an explanation by B[illegible]he decline in[illegible] production appears to be a combination of fewer adults d[illegible]nt and a gre[illegible]r decline in older fish due to higher mortality, although t[illegible] cause of [illegible] in mor[illegible]ity is unknown.

No Action.

Striped bass eggs and larva and juve[illegible]are the lif[illegible]tages direct[illegible] impacted by water diversions in the Delta during the first yea[illegible]e from A[illegible] through th[illegible]fall and sometimes during winter. The impact on eggs, larva[illegible] young ju[illegible]iles occurs [illegible]om April to July with further impacts on juveniles through the [illegible]mmer and f[illegible]hese im[illegible]ts would continue under the No Action Alternative. Total e[illegible]or[illegible] under the N[illegible]native during the spawning and nursery s[illegible]n are roughly [illegible]s average e[illegible]ditions (CALFED 1998, Appendice[illegible] Although [illegible]al exports f[illegible]s alternative are 6.5 % higher than existing ex[illegible]f this inc[illegible] from August to March. The added impact on striped bass d[illegible]riod tends [illegible]ely small in wet years and greater in dry and critical years bec[illegible]er fish res[illegible]n the Delta when flows are low.

It is unclear [illegible]reased exp[illegible] current levels would further deplete the population of yo[illegible] the Delta[illegible]ce they may already be nearly depleted there under current [illegible]port leve[illegible] critical years. Under current conditions the population is likely to c[illegible]tinue to decline [illegible]e of a hatchery stocking program (Department of Fish and Ga[illegible] 1998). In recent y[illegible] striped bass abundance has remained low despite higher than a[illegible]rage delta outflows a[illegible]xport rates, both of which are conducive to strong year cla[illegible]. The most apparent ca[illegible]e is the continuing decline in egg production caused by average lo[illegible] recruitment since the 1[illegible]0's due to entrainment losses and relatively fewer, older, more f[illegible]d adults as a result of l[illegible]wer recruitment and an increase in adult mortality rates.

[illegible]tive 1.

[illegible]ve 1, entrainment of eggs, larvae, and juveniles in the south Delta would [illegible]onal juveniles would be salvaged because of improvements in fish facilities an[illegible] of Clifton Court pre-screen losses. The closure of the cross channel gates through the spawning season from April to June for winter-run chinook salmon protection, would reduce the diversion of Sacramento River striped bass eggs and larvae in comparison to periods when the cross channel gates were open in years before the winter-run criteria went into effect. However, closing these gates may lead to greater negative flows in the San Joaquin River. As in the past, eggs and larvae would move across the Delta from the Sacramento River through Georgiana and Three-mile sloughs and some would be entrained at the export facilities.

Alternative 2.

Under Alternative 2, increased numbers of eggs and larvae would [illegible] diverted and entrained from the Sacramento River because fish screens at the Hood diversion would be inadequate to screen these stages. At the Clifton Court diversion, eggs, larvae, and juveniles would continue to be entrained; additional juveniles would be salvaged because of improvements in fish facilities and elimination of Clifton Court pre-screen losses.

However, adults would be adversely affected because they wo[illegible]ted by the high proportion of Sacramento water in the Mokelumne River and hence bl[illegible] completing their migration by the fish screen at Hood. This problem requires a feasi[illegible]f fish passage. Apparently, it is possible to trap and pass striped bass over su[illegible] whether it is feasible, advisable and cost effective to move several hundred thousand s[illegible] around a structure in a short time, remains to be explored. If trapped adults spawn in the [illegible] River in response to rising temperatures before they are passed a[illegible] the fish scre[illegible] their progeny would be highly vulnerable to Delta diversions [illegible]dal dispersion [illegible] junction of the San Joaquin River and Mokelumne River [illegible] to escape i[illegible]al entrainment. Estimates of the percentage reduction in t[illegible] populati[illegible] bass eggs and larvae in the Delta are substantial under existing conditions. Estimates [illegible] low flow years range from 73.5 to 99.6 percent (DFG 1992). Population reduction[illegible]ly increase if Sacramento River bound fish spawn in the Mokelumne River and that wa[illegible] goes directly to the export pumps.

It is unknown what proportion of the population might use this channel to attempt to access the Sacramento River. If flows diverted at Hood [illegible] a large proportion of the Sacramento flow, as might occur in dry years, more [illegible] might be [illegible]ted to the Mokelumne River as a corridor to the spawning grounds. [illegible] striped bass [illegible]eased in the San Joaquin River are co[illegible]ly recaptured [illegible]ew weeks i[illegible]cramento River above Sacrament[illegible] unknown [illegible]ays from the San Joaquin River to the Sacramento River are [illegible]nt.

Alternative 3.

Increased [illegible] and larva[illegible]uld be diverted and entrained from the Sacramento R[illegible] because [illegible]s at the Hood diversion would be inadequate to screen these stag[illegible]. However, a hi[illegible]ion of the juveniles entrained would be salvaged because of impr[illegible]ements in fish facili[illegible]mination of Clifton Court pre-screen losses. The magn[illegible]de of the diversion of [illegible] larvae from both the Sacramento and San Joaquin rivers, as [illegible] as eggs, larvae and juv[illegible]iles from the San Joaquin, depends on operation of the facilities. Fo[illegible]ample, a temporary re[illegible]ction in diversion at Hood during the striped bass spawning s[illegible] would reduce divers[illegible]n of eggs and larva from the Sacramento River and provide [illegible]rt flow to move yo[illegible]g bass to the nursery areas downstream. If diversions are not [illegible] entrainment [illegible]gg and larva will be high and transport flows will likely be inadequate. [illegible]tions [illegible] not be affected as for Alternative 2 because the facility is isolated. When [illegible] the south Delta, some entrainment would continue for eggs, larvae, and juv[illegible] the San Joaquin River and through other Delta channels. However, because QWEST flows would be improved over existing conditions and less water would be diverted from the south Delta, we expect less entrainment of striped bass and improvement of nursery habitat in the Delta.

2. Can diversion effects in the South Delta be offset by habitat improvements and other common program actions?

Striped bass can use various habitats to rear, including shallow wate[illegible] Any improvements in habitat such as an increase in tidal marshes in Suisun Ba[illegible] Pablo B[illegible] other areas secure from entrainment effects could help striped bass; how[illegible]er, there is no [illegible] determine, a priori, if such habitat change would offset entrainment lo[illegible]s and indirect [illegible]orta[illegible] from transport flow reductions on the Sacramento River. As stated ab[illegible]e, south Del[illegible] diversions have a major impact on the population so habitat improvements woul[illegible]ed to ha[illegible] a large impact to offset existing conditions.

Reduction in toxicants may improve striped bass survival, but [illegible]ave not been identified as a major controlling factor for the striped bass population. H[illegible]lation increases resulting from this program would likely be small.

Some common programs may adversely affect striped bass a[illegible] other f[illegible]ons if nutrients and turbidity are reduced. For example, if nutrients, carbon input, and p[illegible] production are decreased this would reduce the food supply for fi[illegible] Turbidity redu[illegible] result in increased predation on young striped bass and othe[illegible] these comm[illegible] programs are difficult to evaluate, some would likely be a[illegible]er existing conditions.

3. To what extent can alternatives 1, 2, and [illegible] offset div[illegible]sions e[illegible]esently configured?

All three alternatives screen the int[illegible]Clifton C[illegible]urt Forebay [illegible]hich reduces predation and other losses now occurring in Clifto[illegible]urt. The N[illegible]Action cho[illegible] would continue these losses. Screening of agriculture diversi[illegible] would red[illegible]sses of [illegible]e young striped bass which are beyond the egg and lar[illegible]tag[illegible]

Alternati[illegible]

A[illegible]ffers marg[illegible]ved conditions for striped bass compared to existing cond[illegible]mination o[illegible]n young striped bass in Clifton Court Forebay. However, striped[illegible]Delta wou[illegible]posed to large potential entrainment losses due to screen ineffic[illegible]dling mo[illegible] indirect losses. This alternative maintains flows in the Sacr[illegible]w Hood a[illegible]curs under present conditions, providing for faster transp[illegible] striped[illegible]the river and into the lower river and Suisun Bay than either Alternati[illegible] 2 or 3. Striped[illegible] between egg and larva stages increases with increased river fl[illegible] (IESP 1994).

Alt[illegible]ative 2.

Because the Hood di[illegible]sion would reduce transport flows for larvae, potentially result in si[illegible]icant numbers of adu[illegible] spawning in the Mokelumne River, and entrain large numbers of [illegible]d larvae from the S[illegible]cramento River, this alternative would provide worse conditions for [illegible]ass than existi[illegible] diversion conditions. The extent of these impacts is uncertain given the [illegible]ssoci[illegible]ith the above. How these facilities are operated to minimize impacts d[illegible] season is important.

[illegible] a few adults were blocked from migrating to the Sacramento River at Hood, Alternative 2 would likely decrease the entrainment of striped bass in the South Delta by creating more positive net flows in the San Joaquin River. Operation studies indicate that net San Joaquin

River flows at Antioch would be positive for all months of the year and in April-July would be about double the No Action conditions or conditions under Alternative 1. However, these flows are still small relative to the tidal volume. On average, reverse flows would no longer occur on the San Joaquin River (based on operations studies: QWEST, 1921-1994; Flow at Antioch [illegible] 1975-1991).

Alternative 3.

The use of Alternative 3 in lieu of existing conditions for times [illegible] the year other [illegible] the striped bass spawning period would greatly reduce the entrainment [illegible]sses now occ[illegible]ng i[illegible] the south Delta. Additionally, because it is an isolated facility, it woul[illegible]ot attract ad[illegible] fish and this obviates the need to deal with the problem of passing fish past a[illegible] screen a[illegible]Hood as in Alternative 2. The diversion of eggs and larvae during the spawning [illegible] reduced transport flows in the Sacramento River below Hood would decrease t[illegible] of eggs and larvae in that river reach. If the facility were operated to minimize such [illegible] when striped bass spawn and south Delta diversions were also minimized during the [illegible]ursery period, this would provide greatly improved conditions for striped b[illegible]. Posit[illegible] the San Joaquin River would be good for striped bass spawning in the San Joaquin R[illegible]ld move them west to better nursery conditions and away from ent[illegible]nt and impro[illegible] as nursery habitat for striped bass. This alternative scored hi[illegible] matrix exerc[illegible]

5. What is the risk and chances of success of sp[illegible]es recov[illegible] alter[illegible]ative?

The striped bass population has been decli[illegible]g. The adu[illegible] popula[illegible]cted by reduced recruitment as a result of early life stage [illegible]sses witho[illegible] sufficient [illegible]y-dependent survival (compensation) to maintain the num[illegible]of adults [illegible]t were histo[illegible]cally present. Although some compensation is apparently [illegible]rring bet[illegible]en the summ[illegible] abundance in the first year of life and recruitment at age 3, the [illegible]lation of a[illegible]ts, which n[illegible]bered 1.8 million in the early 1970's, has declined to about 700,0[illegible] presently. [illegible]overy c[illegible]ot occur under the No Action Alternative. Alternatives 1 [illegible]d 2 [illegible]ppear to ex[illegible]t striped bass population stresses relat[illegible]using the Delt[illegible]er export c[illegible]rnative 3 still falls short of full restoration [illegible]s populat[illegible] Appendix [illegible]x, page 8), largely because water demands e[illegible]vement o[illegible]ion conditions. Alternative 3, if operated in a manner which [illegible]entrainme[illegible] striped bass, provides the best opportunity for some restoration [illegible]lation.

6. What in[illegible]tion or i[illegible]ovement for fish species will be provided by othe[illegible]ograms s[illegible]Central Valley Project Improvement Act(CVPIA), bi[illegible]gical opinions,[illegible]

[illegible]his is difficult to eval[illegible]e no water has been firmly committed to any striped bass res[illegible]ion scenario. It is unlik[illegible]y that the 800,000 acre feet of water allocated under the CVPIA do[illegible]ng of anadromous fish [illegible]ll cause a doubling of striped bass given the existing export c[illegible]ions and diversion im[illegible]cts.

draft

7. What degree of benefit and impact will the common programs provide?

The common programs will likely provide some benefits for young striped bass, but these are difficult to evaluate. Screening of small Agricultural diversions would reduce mortality of young striped bass. Planned increases in the amount of tidal marsh habitat for nursery areas adjacent to Suisun Bay and San Pablo Bay could increase survival of young striped bass. Reducing point and non-point sources of toxic chemicals and metals could improve conditions for all life stages to some degree, however, present population effects of toxicants have n[illegible] demonstrated. Reduction of organic input and decreasing turbidity may adversely affect striped bass production.

8. What are the direct and indirect effects on fish population[illegible]ting from each alternative and what is the expected response of the popula[illegible]ese effects?
Covered in answers to questions 1-6.

9. What Sacramento River flow is required below a Hood di[illegible]rsion [illegible]almon, striped bass and delta smelt?
Transport flows to move striped bass into the estuary are i[illegible]tant. When l[illegible]s of striped bass eggs and larvae are moving down the Sacram[illegible] diversion sho[illegible]p or be minimized to reduce the impact of entrainment and to [illegible]ansport flow[illegible] promote the survival of larvae. We recommend that fl[illegible] be main[illegible]igh enough level to transport eggs to Collinsville to Rio Vista reach of the river wi[illegible]n [illegible]sing Hood. Reduction of flows below Hood to less than what [illegible]w occurs w[illegible]en I str[illegible]e 13,000 cfs or greater would be detrimental to young striped [illegible]ass.

10. What survival rate can be expect[illegible] striped [illegible]ss eggs and [illegible]arvae and delta smelt passing through Sacramento Ri[illegible] screens a[illegible] pumps in A[illegible]ernative 2?
We would expect that most strip[illegible] bass eggs a[illegible]rvae wo[illegible] be entrained with water diverted at Hood and channeled to [illegible]e p[illegible]mping plant[illegible]rvival would be very low. Some would [illegible]y be caught in [illegible] volume and [illegible] and forth in the San Joaquin River and [illegible]me migh[illegible]nment by m[illegible]g beyond the influence of the pumps, depending [illegible]uin River [illegible]d dispersion in the lower San Joaquin River. However, as p[illegible]dicated, n[illegible]ow relative to the tidal volume which suggests that residence ti[illegible] influence[illegible]s will be long. Modeling of the hydrodynamics mig[illegible] to estima[illegible] proportion of striped bass larvae and juveniles lost to pumping.

11. Sh[illegible]d there be a s[illegible] Sacramento River intake of Alternative 2?
[illegible] screen for striped ba[illegible] larvae, if feasible, would likely be very expensive and diffic[illegible] to maintain in a debri[illegible]te. A screen for salmon juveniles or young striped bass wo[illegible] also be a negative facto[illegible]f it traps striped bass adults migrating through the Mokelumne Ri[illegible] to the Sacramento Rive[illegible] spawning grounds.

[illegible] <u>What are the logi[illegible]l stages for a preferred alternative?</u>
Alternative 3 i[illegible]e preferred alternative for striped bass. It is not clear how this could be [illegible] biological considerations.

draft

Uncertainties

There are many uncertainties in this evaluation, both large and small. Even with further data exploration, there is much that would remain speculative in our assessment of potential benefits and detriments. First, there is the uncertainty regarding how much striped bass entrainment losses will be reduced and access to nursery areas enhanced with positive downstream flows rather than reverse flows in the lower San Joaquin River. Similarly, if Sacramento River flows necessary for larva transport are greatly reduced at Hood, how much will this affect the survival of striped bass left in the river? At this location, transport flows obviously become more important in years of low inflow. The proportion of the adults that would use the Mokelumne River as a migration corridor to the Sacramento River spawning ground is unknown. If that proportion is small, it will have a minor effect, but if it is large, it will have a major negative impact.

draft

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DIVERSION EFFECTS ON FISH

APPENDIX C

CALFED ALTERNATIVE EVALUATION FOR DELTA SMELT

draft

DIVERSION EFFECTS ON FISH

CALFED ALTERNATIVE EVALUATION FOR DELTA SMELT
NARRATIVE

Draft - June 12, 1998

The delta smelt team consists of Michael Thabault, U.S. Fish [illegible] Wildlife S[illegible]ice, Larry Brown, U.S. Bureau of Reclamation, Dale Sweetnam, Department of [illegible]h and Ga[illegible]e, and Chuck Hanson, State Water Contractors. Those who participated in the creat[illegible] the [illegible]st draft of the matrices include Michael Thabault, Larry Brown, and Dale Sweetnam[illegible]

The scale of each matrix box (pages C24-C29) ranges from +3 t[illegible]3[illegible]resses the relative impact of the effects identified that would affect delta smelt i[illegible]relation[illegible] diversions. Entries were based on a qualitative discussion of the degree to which [illegible]r proposed operations impact the delta smelt population. The valu[illegible]each box rep[illegible] combination of two estimates on the part of the Team: 1) the [illegible]fect on the de[illegible]t population if exposure occurs, and 2) the probability that [illegible]ll be exposed[illegible] Therefore, caution should be used in interpretation of t[illegible] matrix v[illegible]xample[illegible]xposure to toxicants includes the likelihood that fish will be [illegible]posed in ad[illegible]tio[illegible]t on the possible effects to the individuals that experience t[illegible] exposure[illegible]

The delta smelt matrices were divide[illegible] “wet ye[illegible]” and “dry y[illegible]ars” because distribution is strongly tied to hydrologic c[illegible]ons and t[illegible] effects (pos[illegible]ve or negative) of potential actions in the delta potentially w[illegible]d be damp[illegible]d in “wet y[illegible]rs”. The differences between the magnitude of the effects in [illegible]t and dry y[illegible]s discus[illegible] in the narrative.

Definitions [illegible]d Assumpti[illegible]

Entrainme[illegible] [illegible]ent is def[illegible]direct effects of entrainment of delta smelt at the Cenral Valley [illegible] State Wate[illegible]mping plants. Agricultural diversions are treated separately [illegible]nsideration[illegible]e diversions was not included in the charge to the group. Also, [illegible]eration wo[illegible]re documentation and model runs for any changes in opera[illegible]part of C[illegible]FED or possible interactions of present operations w[illegible] changes i[illegible]itions that would result from the CALFED alternatives. The direc[illegible]ffects considered[illegible]inment and loss through export; 2) predation in Clifton Court F[illegible]ebay and any other p[illegible]elated to screens; and 3) losses due to handling of fish at fish s[illegible]vage facilities. The en[illegible]nt score represents an overall effect of the three factors. Th[illegible]atrix includes rows for t[illegible]e three factors but the three rows may not necessarily add up to th[illegible]al effect score assigne[illegible]o entrainment. The extra scores are meant to indicate the relative i[illegible]tance of the various f[illegible]tors included in entrainment.

draft

Hydrodynamics: Hydrodynamics is defined to include the indirect effects of holding delta smelt in the interior Delta longer than would occur under more natural flow conditions. We assumed that the mortality rate in the interior Delta is higher than that in Suisun Bay, where most juvenile rearing occurs. Thus, the effect does not imply changes in mortality rates but differing durations of exposure to different mortality rates. The higher mortality rate was presumed to occur through longer exposure of delta smelt to undefined mortalities that occur in the central [illegible]. These sources of mortality could include predation by species common in the Delta such [illegible] largemouth bass and silversides, differences in water quality, or differences in food production and availability in different areas. The Team recognizes that this assumption is based on sparse data but the view is consistent with the existing view of delta smelt ecology (Moyle et al. 1992, U.S. Fish and Wildlife Service 1995a,b). The environmental cues delta smelt use to migrate to Suisun Bay (assuming active rather than passive transport) are unknown [illegible] the simplest assumption is that they can detect or use the net direction of water movement [illegible] combination with tidal flux to choose a migration path. If this process is correct, delta [illegible] would be transported, either actively or passively, in the direction of the net flow [illegible] the modeling runs that form the basis of the assessment. The effects of hydrodyna[illegible] assessed by explicitly considering the following geographic locations identified in modeli[illegible] Cross Delta flow; 2) Qwest; 3) Old River @ Bacon Island; 4) Sacramento River at Rio Vi[illegible] Joaquin River at Antioch.

Predation: Predation includes all predation other than that occurring [illegible] Court Forebay and in front of screens.

Handling: Handling losses are included in entrainment. Handling is associated with a very high level of mortality given the delicate nature of delta smelt.

Food supply: Recent studies of delta smelt feeding indicate that the availability of appropriate food types may be very important at certain points in the delta smelt life cycle and for overall survival (Nobriga 1998, Lott and Nobriga in prep.). [illegible] summarizes the best guess of the team as to the effects certain [illegible] will have on [illegible] of food to the population.

Shallow-water habitat: Assessments of shallow-water habitat are based on possible effects on spawning habitat and food supply. [illegible] assumes that the majority of shallow-water habitat rehabilitation will [illegible] perennial tidal [illegible] located in the interior Delta. Nothing definitive is known about the [illegible] delta smelt for [illegible] tidal marsh habitat. This type of habitat is known to be used [illegible] it is uncertain [illegible] spawning habitat is limited under present conditions. There is no [illegible] evidence that this habitat is used as rearing habitat. Past assessments of delta smelt e[illegible]st that shoal habitat is important in Suisun Bay (Moyle et al. 1992, U.S. Fish and Wildlife Service 1995a,b) indicating that rehabilitation of shoal habitat in the western Delta might provide some benefit. However, ongoing studies of delta smelt habitat use suggest that larval and juvenile delta smelt are not selecting the shallow (<3m) edges of [illegible] channels compared to the deeper mid-channel areas (Sweetnam, unpublished data). Given the uncertainty in location and types of habitats to be rehabilitated and the benefit of shallow-[illegible] habitat as rearing habitat, shallow-water rearing habitat was not considered in the [illegible]ent.

[illegible]perature): The Team believed that none of the alternatives would have a ma[illegible] in-Delta water temperatures. This row was scored 0 through all matrices; therefore it was omitted from the matrices.

draft

Salinity/X2 (originally called Water quality (salinity)): For delta smelt, the original "Water quality (salinity)" row was changed to Salinity/X2. We believe this better defines the variable of interest for delta smelt.

Agricultural diversions: The Team assumed an aggressive program of scr[illegible]ning and [illegible] consolidation of in-Delta agricultural diversions. Screen design was assu[illegible] have so[illegible] benefit for various life stages of delta smelt

Sources of uncertainty

The Team identified many sources of uncertainty. New data a[illegible] The major areas are identified below. Additional text is provided in the narrative for ea[illegible]lternatives.

We do not know the absolute size of the delta smelt population. A[illegible]d on sampling data from the various existing monitoring program[illegible]ncluding[illegible]hannel vs. shallows larval sampling; 2) the 20-mm estuary-wide juvenile survey ([illegible] flooded tracts); 3) Real-time Monitoring Program; 4) mi[illegible]trawling; 5) [illegible] trawling; and 6) fish salvage at the state and federal [illegible]ts. The Tea[illegible] considered all of these relevant programs to mini[illegible]ight result [illegible]om considering data from any single sampling me[illegible]d or sam[illegible]

Screening criteria for both large project scree[illegible]and smalle[illegible]gricultu[illegible]s are unknown. Benefits for delta smelt are as[illegible]med; how[illegible]er, recent b[illegible]avioral studies suggest that it may be very difficult t[illegible]gn scree[illegible]that actuall[illegible]benefit delta smelt to a significant degree (Swanson et al 1[illegible] It was al[illegible]assumed th[illegible]e was some benefit to all life stages, which may not be t[illegible]ase depen[illegible]g on final s[illegible]en design.

The benefit[illegible]of shallow-water [illegible]rehabilitati[illegible]lt are unknown. Such habitat is us[illegible]spawning an[illegible]ribute to o[illegible]uctivity of the system. It is not kn[illegible]wning ha[illegible]ing factor for the population. Shallow-water habitat is not [illegible]e an impo[illegible]habitat for delta smelt. The Team assumes that the ma[illegible]llow-water [illegible]bilitation will involve perennial tidal marsh located in [illegible]Delta. No[illegible]ve is known about the need of delta smelt for perennia[illegible]habitat. [illegible]o compelling evidence that this habitat is used as r[illegible]t assessm[illegible]s of delta smelt ecology suggest that shoal habitat is im[illegible]tant in Sui[illegible]oyle et al. 1992, U.S. Fish and Wildlife Service 1995a,b) in[illegible]ating that rehab[illegible]oal habitat in the western Delta might provide some [illegible]nefit. However, ong[illegible]es of delta smelt habitat use suggest that larval and juvenile delta smelt are[illegible]ecting the shallow (<3m) edges of the channels compared to the deeper mid-cha[illegible]el areas (Sweetnam, unpublished data). Given the uncertainty in location and types of habitats to be rehabilitated and the benefit of shallow-water habitat as rearing habitat, shallow-water rearing habitat was not considered in the assessment.

We have little understanding of in-Delta predation dynamics on delta smelt.

As indicated at several points above, we have relatively little understand[illegible]g of limit[illegible] factors for the delta smelt population. Recent studies suggest that [illegible]bility of [illegible] food types at specific times may be very important (Nobriga 199[illegible] Lott and Nobri[illegible] prep.).

draft

Existing Conditions

Entrainment: Entrainment values are based on historical salvage of delta smelt at the water project diversions in the South Delta. The strongest negative effects occur in the late sprin[illegible]arly summer when young-of-the-year delta smelt become large enough to be counted as salva[illegible]he facilites in May, June and July. Entrainment of larval and early juvenile del[illegible]smelt < 2[illegible] not counted as take at these facilities, therefore salvage data does not rep[illegible]larval loss[illegible] entrainment and the peak effect might be prior to the salvage peaks obs[illegible]ed in May or J[illegible] Screening efficiencies and pre-screening losses (e.g., predation) for de[illegible]smelt are no[illegible]own [illegible] actual losses of delta smelt cannot be calculated. We assume that sig[illegible]cant predati[illegible]occurs on delta smelt entrained into Clifton Court Forebay, however it may be [illegible]arable t[illegible]other species of the same size and shape (and swimming ability). The Team ackno[illegible]t there are differences among life stages in the probability of survival to reproduc[illegible]arlier life stages having lower probabilities but without carefully designed and imp[illegible]udies of life-stage specific mortality rates, the magnitude and importance of the diff[illegible]en[illegible]ain. The Team did qualitatively consider the relative importance of larval, ju[illegible]nile, and [illegible]ts.

Delta smelt usually do not survive the handling process, therefo[illegible]arger the pot[illegible] handling smelt, the larger the potential negative effect. Han[illegible]smelt was a[illegible] assumed to be proportional to entrainment effects. More [illegible]ined in dry years therefore the potential for handling mortality increases. Survival [illegible]influen[illegible]ed by water temperature, which would be higher in dry ye[illegible]s.

Secondary effects of moving delta smelt out of [illegible]mal delta [illegible]melt rearing [illegible]reas is covered under hydrodynamics.

The negative effects of entrainment are s[illegible]gest in dry [illegible]ars when a l[illegible]ger proportion of the population is located in the delta for a lo[illegible]er period o[illegible]. In we[illegible]ears, the population is more widely dispersed and distributed f[illegible] th[illegible] Delta to Su[illegible]econd period of entrainment occurs in the [illegible]winter and ea[illegible]when pre-sp[illegible]ults move to freshwater to spawn.

Hydrodynam[illegible]fects of proj[illegible]hydrodynamics on delta smelt occur mainly in the spring and su[illegible]s when pr[illegible]dults move upstream to spawn and young-of-the-year delta sm[illegible]nt in fresh[illegible]ore migrating to brackish water in the summer. The res[illegible]smelt are [illegible]ally associated with the low salinity areas of the estuary west [illegible]the Delta, p[illegible]uisun and Grizzly bays. The negative effects of hydrodyn[illegible]ics in dry years [illegible]nd longer in duration than in wet years (DWR 1994, Biologi[illegible]l assessment of ...).

Cr[illegible]**Delta Flow:** There ma[illegible]ctually be some Cross-Delta flow in wet years but little effect is ex[illegible]ted because of general [illegible]gh outflow conditions in wet years. In dry years, Cross-Delta f[illegible]will be [positive] larg[illegible]and tend to move delta smelt spawned above the Delta Cross-[illegible]l toward the centr[illegible]and southern Delta channels. The modeling studies used in this [illegible]nt use the va[illegible]e Cross Delta Flow which combines flows in Georgiana Slough, the [illegible]Ch[illegible]and Snodgrass Slough/Alternative 2 discharge. The modeling runs p[illegible]at the Delta Cross Channel Gates are open from 1 July to 1 November. Part[illegible]ng results verify that Cross-Delta flow occurs through Georgiana Slough when the Cross Channel Gates are closed.

draft

Qwest: Qwest is generally positive over the period of record so it was assumed that Qwest would be positive in wet years and there would be little effect on delta smelt. In dry years, Qwest is negative in most months and only slightly positive in the remaining months. As [illegible] described earlier, the retention of delta smelt in the Delta was felt to be a significant nega[illegible] effect on the population, particularly for larvae and juveniles in the spring m[illegible]nths.

Old River @ Bacon Island: Based on the 1975-1991 period of record [illegible]yzed, flow in [illegible] River was negative during all months. Spawning in wet years is diffus[illegible]nd significan[illegible]spawn[illegible] can occur in the central and southern Delta. A slight negative effect w[illegible] assigned in [illegible]e winter because adults could be induced to spawn farther south than they wo[illegible]therwis[illegible]nd larvae and juveniles spawned in the area would be held in the area of the pumps [illegible] D[illegible]ing dry years negative flow in the area is assumed to be high. This negative flow is [illegible] retain larvae and juveniles in the southern Delta and this is presumed to have a negati[illegible]n survival. Particle-tracking model results indicate that 62% of the particles injecte[illegible] are exported from the pumping facilities within 20 days. This suggests [illegible]t weak[illegible] larvae are likely moved toward the pumps for some period of time, even if they a[illegible]tly entrained.

Sac River @ Rio Vista: Sacramento River flow is strong[illegible] wet years w[illegible] no effect expected on delta smelt. Sacramento River flow [illegible]ill be lo[illegible]rs but [illegible]s is not felt to be a major effect on the delta smelt population. Most of th[illegible] neg[illegible] already implicitly included in the Qwest effect indicated a[illegible]ve. In dry [illegible]ears, de[illegible]ccumulate in the Sacramento River and will be subject to the [illegible]west effect. The delta sm[illegible]emaining in the more upstream portion of the Sacramento Ri[illegible]ere also f[illegible]t to be nega[illegible]vely affected, but not to the degree of the rest of the population. [illegible]nt regula[illegible]y requireme[illegible]s in the 1995 Water Quality Control Plan limits the movemen[illegible] X2 into th[illegible]acramento [illegible]ver channel. The Team believed a relatively small proportion of [illegible]e populatio[illegible]d the po[illegible]n of the Sacramento River above Hood for spawning in dry y[illegible]rs.

San Joaq[illegible] @ Antio[illegible] [illegible]in River flo[illegible]kely stay positive during all months during we[illegible]ittle effect [illegible] delta smelt. In dry years, flow in the San Joaquin River is dram[illegible]ced. Signi[illegible]e flows occur in some months. Moyle et al. (1992) hypothesi[illegible] is a negat[illegible] the delta smelt population. The negative values for this para[illegible]te longer r[illegible]ime in an area where survival was believed to be relatively poo[illegible] might a[illegible]e vulnerable to moving into areas subject to the other effects [illegible]cribed ab[illegible]d River flows).

Predati[illegible]: There were two m[illegible] predation that were considered for delta smelt: larval preda[illegible]n by inland silversides [illegible]edation at structures other than screens by striped bass, larg[illegible]outh bass, etc. Predation effects are diminished in wet years when the smelt population w[illegible]idespread with a larger proportion out of the Delta. The potential for inland silverside p[illegible]tion appears to be gre[illegible]st in drier years when the majority of the population spawns above [illegible]nfluence. Predation on adults was considered to be relatively low with the effect [illegible]ing in months when larvae and juveniles are present.
[illegible]: R[illegible] studies suggest that *Eurytemora affinis* is a preferred food item of delta s[illegible], Lott and Nobriga in prep.). Redutions in *Eurytemora* abundance through the int[illegible] exotic species such as clams (*Potamocorbula*) and copepods (*Psuedodiaptomus*, *Sinocalanus*, etc.) has led to the potential for food limitation for delta smelt. Wet years provide

higher levels of food production in the estuary and decrease the effects of the clam on the ecosystem.

The negative effect of exporting a proportion of the food production with withdrawal [illegible] water from the estuary was also considered. This effect was not considered importa[illegible] wet years. In dry years a negative effect was assigned. The negative eff[illegible] appears [illegible] than direct effects of entrainment because the Team felt that earlier [illegible] of prim[illegible] production, nutrients, and zooplankton might have some effect on p[illegible]uctivity later [illegible] season, even though fish were not present.

Shallow/Nearshore Habitat: Shallow or nearshore habitat is import[illegible] delta smelt as spawning habitat. It is not believed to be as important to delta smelt a[illegible] habitat. It was difficult to assign a value to this for two reasons. First, while it is clea[illegible] habitat has declined it is unkown whether spawning habitat is a limiting factor on th[illegible]. Effects were assigned during the spawning season from December through Ma[illegible]ertainty with the existence and magnitude of any effect is very high. Even th[illegible] the [illegible] amount of available spawning habitat varies between wet and dry years the team [illegible] that the magnitude of the effect varied enough to warrant a change in [illegible] especially g[illegible]l of uncertainty involved. Second, the Team also believes tha[illegible]ter habitat m[illegible] some value as a source of nutrients and production to the [illegible]

Water Quality (Temperature): Delta water temper[illegible]ures are no[illegible] project operations. As water temperatures increase in the [illegible]ta, delta sm[illegible]lt are th[illegible]ove to cooler portions of the estuary, therefore the delta smelt [illegible]am decided [illegible]at there w[illegible] effect" of temperature on delta smelt for either water y[illegible]pe.

Water Quality (Salinity/ X2 Position): [illegible] delta sme[illegible]am decided [illegible]at the effects of salinity on delta smelt are best described by the [illegible]tionship b[illegible]n delta [illegible]lt abundance and X2 position. Delta smelt are most abu[illegible]hen X2 is [illegible]un Bay in the spring. Although the [illegible]ionship is so[illegible]ak, it does [illegible]atistically significant proportion of the vari[illegible]t 20%). [illegible]ch of the va[illegible]ity in the delta smelt population is unaccount[illegible] alone. M[illegible] of X2 position is mainly dependent on freshwater inflow to the [illegible]wet years, [illegible]radient has little effect on delta smelt except in the summer mon[illegible]tflow decl[illegible] gradient moves upstream into the Delta. In dry years, the effect[illegible] may be m[illegible]r and last from February through November. The months of Fe[illegible] April were [illegible]n positive effects in order to reflect export limitations a[illegible] X2 flow r[illegible] under the 1995 Water Quality Control Plan.

Agricu[illegible]ral Diversions: Th[illegible] 1800 agricultural diversions in the delta, which at times in the [illegible]mmer may export a si[illegible]agnitude of water as the export facilities in the south delta. Ad[illegible]onal agricultural diversi[illegible]s in Suisun Marsh have the ability to entrain delta smelt when th[illegible]pulation is located farth[illegible] downstream in Suisun Bay. Not only do these exports have the p[illegible]ial to entrain larval a[illegible] juvenile fishes, plankton and nutrients are also diverted. There may [illegible]cultural diversion [illegible]ects on delta smelt year round in different areas of the estuary, [illegible] the majority [illegible]mpact would be at high levels of diversion in the spring and summer.

No Action Conditions

Entrainment: Based on modeling runs the majority of the increased diversions resulting from the 2020 level of demand would occur in December-March and July-August. The largest increases in exports (resulting in higher levels of entrainment) occur in February and Ma[illegible] wet years, and December-March in dry years. During this period, pre-spaw[illegible]g adults [illegible] entrained at higher rates. The July increase in wet years was given a gre[illegible]ffect beca[illegible] young-of-year delta smelt are more likely to be in the area at that time c[illegible]pared to Augu[illegible]

Hydrodynamics: Changes in hydrology based on the increased level[illegible]demand ar[illegible]milar to existing conditions with increases in negative effects observed throug[illegible]t the wi[illegible]r and spring. The magnitude of the effect might be greater in wet years since additi[illegible] would be available to be exported in the spring. Negative effects were lessened [illegible] both year types for export constraints already in place. The reduction did not carry thro[illegible]ause protections are curtailed while large numbers of young smelt are still p[illegible]uin River at Antioch appeared slightly worse in December and January, which[illegible]ay have [illegible] adult delta smelt staging to move into the Delta.

Predation: No change from existing conditions for wet yea[illegible]ditional effec[illegible]y years there is the potential for increased effects in the wi[illegible] water is ex[illegible]orted; however, no changes in scores were made.

Handling: No change from existing conditions fo[illegible]wet years w[illegible]n no add[illegible]ect. In dry years there is the potential for increased effects i[illegible]he winter[illegible]hen additio[illegible]water is exported; however, no changes in scores were made.

Food Supply: With increased exports in[illegible] winter, hig[illegible] levels of p[illegible]ary production and zooplankton are also exported. The team[illegible]ecided that[illegible]dditio[illegible]ffect would be observed in December and [illegible]anuary.

Shallow/N[illegible]Habitat: [illegible]d level of de[illegible]and in the No Action Alternative would not change[illegible]r effect o[illegible]arshore habitat.

Water Quality ([illegible]re): No ch[illegible]isting conditions.

Salinity/ X2 Pos[illegible] to the mod[illegible]g runs available, there is little discernible difference in[illegible] position [illegible] existing and no action conditions. The numbers in the matrix ref[illegible]ct these numbers[illegible]nsideration of the group our original comments were: With in[illegible]eased exports in the [illegible] early spring, there might be additional effects on habitat condi[illegible]ns in the spring. In we[illegible] these effects may be observed in January and February if rai[illegible] occurs later in the spri[illegible]. In dry years the effect may be observed from December th[illegible]gh March. Our original[illegible]omments were based on extrapolations from total Delta outflow.)

[illegible]ltural Diversions[illegible]nless there is same change in demand, no change in existing [illegible]s is anticipat[illegible]

draft

Common Programs

Entrainment: The Common programs do not address this issue.

Hydrodynamics: The Common programs do not address this issue.

Predation: The Common programs do not address this issue.

Handling: The Common programs do not address this issue.

Food Supply: Restoration programs and increases in Shallow/nearsh[illegible] habitat [illegible]ay lead to increases in primary production, which may be a benefit year round.

Shallow/Nearshore Habitat: Additional shallow/nearshore habitat may [illegible]a smelt in terms of spawning habitat. Shallow water areas as nursery habitat do n[illegible] app[illegible]hat important to delta smelt. This benefit is uncertain because there is n[illegible] evidence [illegible] shallow/nearshore habitat is a limiting factor on the population.

Water Quality (Temperature): Common programs may af[illegible]erature of wa[illegible]ning into the Delta but no in-Delta change is anticipated.

Salinity/ X2 Position: The Common programs do n[illegible] address th[illegible] issu[illegible]

Agricultural Diversions: There is a net benefit [illegible] screening [illegible]r delta sm[illegible] which may be observed throughout the entire year. The lar[illegible] magnitude [illegible] a positive [illegible]nefit of screening would be observed in months when delta s[illegible]are in clo[illegible] proximity t[illegible]gricultural diversions and demand is high. This assumes that s[illegible]ening criter[illegible]nd diversi[illegible] consolidation can be designed to minimize effects on all life [illegible]ges of delta [illegible]t. Bene[illegible] will have to be adjusted if only certain lif[illegible] stages are benefit[illegible] T[illegible]s benefit in[illegible]g and consolidation in Suisun Mars[illegible]

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Alternative 1

Alternative 1 was assumed to be the result of the benefits of the common programs above the existing conditions added to the No Action Alternative (expressed as Alt 1 = (Common Programs - Existing Conditions) + NA). See the text for the No Action alternative for explanations of factors.

Entrainment:

Hydrodynamics:

Predation:

Handling:

Food Supply:

Shallow/Nearshore Habitat:

Water Quality (Temperature):

Water Quality (Salinity/ X2 Position):

Agricultural Diversions:

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Alternative 2

Entrainment: Increased exports from the southern Delta in December through March in all years were assigned a large negative effect because of the size of the increase (about 3,00[illegible]fs). A similar large increase occurred in July and August.

Less effect was assigned to direct entrainment at the times of the [illegible]hen delta [illegible] would be large enough for effective screening, if screens with the corre[illegible]iteria can be designed. Additional negative effects were assigned to handling beca[illegible] screened fis[illegible]ll ha[illegible] to pass through a bypass system. Clifton Court Forebay predation eff[illegible]s are now d[illegible]ned as taking place in front of the screens rather than in the Forebay proper. [illegible] greate[illegible]ffect in dry years results from a larger proportion of the population experiencing [illegible]

Hydrodynamics: In wet years, modeling results indicate improvements [illegible]owever, Cross-Delta flows and Flows at Old River @ Bacon Island get worse. [illegible]hes[illegible]ffects outweigh the improvement in Qwest. In dry years, the negative effe[illegible]s are ma[illegible]ecially for Cross-Delta flow and Old River at Bacon Island. Reductions in flow of the S[illegible] River were also assigned a negative value. Qwest remained fav[illegible]except for Ju[illegible]d August, when slight negative effects were assigned. Conditi[illegible]n Joaquin Ri[illegible] Antioch remained favorable all year. The large negative [illegible] 2 is linked [illegible]ot only to hydrodynamic changes but to interactions with the [illegible]sical cha[illegible] The T[illegible]am believes that with this alternative any net productio[illegible] delta sm[illegible]to [illegible]new" canal would be completely lost. It also seemed possible[illegible]at young-o[illegible]year pr[illegible]he west of the new canal could be at risk if tidal action periodic[illegible]ly moves [illegible]ung-of yea[illegible]and out of the areas influenced by the new canal. It seems likely [illegible]hydrody[illegible]ic effects o[illegible]east-west (more or less) tides on the water moving north-sout[illegible]ore or less[illegible]n the canal [illegible] be complex and difficult or impossible to model with exi[illegible] tools.

Predation: No[illegible]change from Alte[illegible]ive[illegible].

Food Sup[illegible]ange from[illegible]1.

Shallow/Near[illegible]tat: The p[illegible]fits of shallow/nearshore habitat were reduced because strong C[illegible]lows would[illegible]value of such habitat within the influence of the diverted water.

Salinity/ X2 [illegible]sition: No[illegible]m Alternative 1.

Agricu[illegible]ral Diversions: No[illegible]om Alternative 1.

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Alternative 3

Entrainment: The isolated facility reduces entrainment effects substantially and a large positive benefit (compared to existing conditions) is assigned. Reduction in predation is assigned [illegible] similar benefit. There is still some pumping from the South Delta and some negative eff[illegible] still assigned to the fish that would go through the bypass facility.

Hydrodynamics: Alternative three improves Cross-Delta and Old Rive[illegible]ows substanti[illegible] resulting in substantial improvement for delta smelt. Positive benefits [illegible] assigned to i[illegible]rease[illegible] San Joaquin River flows in this alternative because there is no longer [illegible] complicat[illegible] interactions with Cross-Delta and Old River flows, which stay positi[illegible] all mo[illegible]s.

In dry years positive benefit was assigned to Old River at Baco[illegible]cause negative flows were reduced and in February-June were near zero.

Predation: Predation in the Delta declines because hydrodynamics [illegible] now fa[illegible] fish are no longer held in the Delta for an extended period of time.

Food Supply: No major change from Alternative 1.

Shallow/Nearshore Habitat: No change from Altern[illegible]e 1.

Salinity/ X2 Position:

Modeling results indicate a decrease [illegible] position [illegible] roughly 2 [illegible]ometers in July and 6 kilometers in August (also 4 kilometers in [illegible]ember). T[illegible]s was given [illegible] positive benefit though it seems inconceivable to the Team that t[illegible]s not a mi[illegible]e. Why w[illegible]d Alternative 3 be operated in this way?

Agricultural [illegible]rsions: No [illegible] Alternati[illegible]

Primary Issues

9. Which species, populations, and life stages are most sensitive to diversion effe[illegible] under no action and alternatives 1, 2, and 3? When and where are they mos[illegible] affected?

No Action: Larvae and young juveniles are the most sensitive li[illegible]stages. These l[illegible] stages are present in the spring and early summer. The major e[illegible]cts occur in th[illegible] centr[illegible] and south Delta where altered hydrodynamics and entrainmen[illegible]e importan[illegible]s delta smelt become adults, they migrate downstream to brackish wa[illegible]reas in[illegible]e fall and winter and are considered less vulnerable to diversion effects. [illegible]ng adults migrating back into freshwater to spawn in the late winter and [illegible] become vulnerable to entrainment effects once again.

Alternative 1: The same as No Action.

Alternative 2: Larvae and young juveniles are still the m[illegible]sitive stages [illegible] vulnerable at the same times. The major changes in [illegible]cs anticipate[illegible] Alternative 2 are believed to be a negative factor f[illegible] delta smel[illegible]ut especially these sensitive stages. These negati[illegible] effects a[illegible] be m[illegible] severe in the eastern Delta.

Alternative 3: Alternative 3 was given h[illegible]h benefit b[illegible]ause of its [illegible]sitive effects on returning Delta hydrodynamics to a [illegible] “natural” [illegible]ondition, m[illegible]ning the rivers and most channels maintain positive o[illegible]s at most[illegible]mes and pla[illegible]. Positive benefits for delta smelt may be high compare[illegible] other spec[illegible] because it [illegible]e only species to complete its entire life cycle in t[illegible]estuary.

2. Can [illegible]sion effects i[illegible]h Delta be [illegible]abitat improvements and ot[illegible]n progra[illegible]

No, co[illegible]am actions [illegible]uncertain effects for delta smelt but it seems unlikely t[illegible]ive benefit[illegible]gh the entrainment and hydrodynamic effects.

3. To w[illegible] extent ca[illegible]es 1, 2, and 3 offset diversions effects as presently co[illegible]gured?

Alternative 1: Little e[illegible]

Alternative 2: Make[illegible]hings much worse.

Alternative 3: M[illegible]es things better.

[illegible]t can diversion effects be offset by modifications to the alternatives or [illegible]onal changes?

(Not to be answered yet)

5. What is the risk and chances of success of species recovery for each alternative?

For the delta smelt team recovery is defined in "The Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes" (Attachment 1). Alternative 1 is n[illegible] major change and probably has little influence on probability of rec[illegible]ery. Alte[illegible] seems likely to negatively affect probability of recovery. Alternat[illegible]eems lik[illegible] improve the probability of recovery. All of these assessments a[illegible]ubject to the uncertainties already identified above.

6. What increment of protection or improvement for delta s[illegible] will be [illegible]ovided by other programs such as the CVPIA, biological opinions?

The protections set forth for delta smelt under the Biological Op[illegible]WS 1995a) on the operation of the State and Federal water project diversions a[illegible]nditions set forth in the 1994 Water Accord and therefore are conside[illegible] part o[illegible] conditions known as "existing conditions" in the model runs provided.

7. What degree of benefit and impact will the comm[illegible] provide?

We estimated that improvement would occur w[illegible] the com[illegible]ms. Mu[illegible] of the benefit predicted is due to the creation of add[illegible]onal shall[illegible] w[illegible]everal different types. The effect on delta smelt i[illegible]ncertain. [illegible]uch of t[illegible]nty stems from the scarcity of evidence of the effe[illegible] of increasi[illegible] such hab[illegible] Delta smelt use such habitat for spawning but it seem[illegible]be of no s[illegible]cial importa[illegible]e as rearing habitat. There is no evidence that spawning[illegible]at is a li[illegible]ing factor fo[illegible]he delta smelt population. While the habitat wil[illegible]o be favor[illegible]e for predat[illegible]s, the increased spawning habitat and possible in[illegible]ases in Del[illegible]mary p[illegible]ctivity and food supply were believed to be possibl[illegible]ts and wer[illegible]efits even though this is an area o[illegible]h uncertainty[illegible] Delta div[illegible]mproved Delta water quality are als[illegible]d to be be[illegible]

8. What a[illegible]t and indire[illegible]n delta smelt populations resulting from each Alternati[illegible]is the expe[illegible]e of the populations to these effects?

The impr[illegible]tions for A[illegible]natives 1 and 2 are purely a result of the benefits assig[illegible] to the co[illegible]ams. Neither of these alternatives improves in-Delta hy[illegible]odynamics to a s[illegible]egree, and the team believes that Alternative 2 will result i[illegible] hydrodynamic cond[illegible]re significantly worse than any other alternative. Alternative 3 performs [illegible] delta smelt because the hydrodynamic changes associated with this alternative ap[illegible]ear likely to have positive effects on the delta smelt population in addition to the positiv[illegible]effects of the common programs.

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A summary of our assessments suggest that Alternatives 1 and 2 will aid the delta smelt population somewhat, through improvements related to the common programs, and that Alternative 3 represents a significant improvement. However, it is unclear if the population will actually benefit to the degree anticipated in this document. Recent [illegible] studies suggest that the success of the delta smelt population might be linked to ti[illegible] and abundance of particular food organisms. Further, the ecology of [illegible]hese food [illegible] organisms may be linked more to the effects of introduced predat[illegible] competi[illegible] to the issues addressed in the alternatives. If this is actually the [illegible]e, then the anti[illegible] beneficial effects of the alternatives for delta smelt might not a[illegible]ally be achie[illegible].

9. What Sacramento River flow is required below a Hood di[illegible]ion to pr[illegible]ect delta smelt?

10. What survival rate can be expected for delta smelt passing th[illegible]ugh Sac[illegible]ver screen and pumps in Alternative 2?

11. Should there be a screen on the Sacramento Ri[illegible] intake o[illegible] 2?

Yes.

12. What are the logical stages for [illegible]eferred al[illegible]native?

13. Wh[illegible]nge of b[illegible]ria that shou[illegible]e considered in the operations of the thr[illegible]s?

References
(including Attachment 1)

Moyle, P.B., B. Herbold, D.E. Stevens, and L.W. Miller. 1992. Life history and status of delta smelt in the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society.121:67-77.

Swanson, C. P.S. Young and J.J. Cech. 1998. Swimming performance of delta sm[illegible] maximum performance, and behavioral and kinematic limitations on swimming [illegible] submaximal velocities. Journal of Experimental Biology: [illegible]1, 333-34[illegible]

Sweetnam, D.S. and D.E. Stevens. 1993. Report to the Fish an[illegible] Commission: a status review of the delta smelt, (*Hypomesus transpacific*[illegible]lifornia. California Department of Fish and Game. Candidate Statu[illegible]-DS.

U.S. Fish and Wildlife Service. 1995a. Formal consultation and conferen[illegible]fects of long-term operation of the Central Valley Project and the State Wa[illegible] on the threatened delta smelt, delta smelt critical habitat [illegible]d proposed [illegible] Sacramento splittail, March 6, 1995. U.S. Fish a[illegible] Service, Po[illegible] Oregon. 52pp.

U.S. Fish and Wildlife Service. 1995b. Sacramento-San Jo[illegible] Fishes Recovery Plan. U.S. Fish and Wildlife service, Portland, Or[illegible]pp.

Attachment 1

The following is the Recovery section of the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes for delta smelt (USFWS 1995b), pages 29-34 and 37-38:

RECOVERY

Recovery Objective

The objective of this part of the Delta Native Fishes Rec[illegible]y Plan [illegible] to remove delta smelt from the Federal list of threatened species through [illegible] of its abundance and distribution. Recovery of delta smelt should not [illegible] expense of other native fishes. The basic strategy for recovery is to manage t[illegible] in such a way that it is a better habitat for native fish in general and delta s[illegible]ar. Improved habitat will allow delta smelt to be widely distributed [illegible]rougho[illegible] and Suisun Bay, recognizing that areas of abundance change with season. Re[illegible] delta smelt will consist of two phases, restoration and deli[illegible] Separate re[illegible] and delisting periods were identified because it is poss[illegible]toration crit[illegible] be met fairly quickly in the absence of consecutive [illegible]ears (I. e.[illegible] extremely wet or dry years). However, without the [illegible]opulatio[illegible]ed by [illegible]xtreme outflows there is no assurance of long-term sur[illegible]val for the [illegible]pe[illegible]toration is defined as a return of the population to pre-de[illegible]ine levels [illegible]ut delis[illegible]t recommended until the population has been [illegible]ested by [illegible]treme out[illegible]ws. Delta smelt will be considered restored when its populati[illegible]ynamics [illegible]nd distribut[illegible]n pattern within the estuary are similar to those that existe[illegible]he 1967-[illegible]81 period. [illegible]his period was chosen because it includes the earlie[illegible]continuous [illegible]ta on delt[illegible] smelt abundances and was a period in which populations st[illegible]ed reason[illegible]high in [illegible]ost years (see below for a more detail[illegible]d justification). Th[illegible]sp[illegible]cies will be [illegible] recovered and qualify for delisting wh[illegible]goes throug[illegible]ear period [illegible]des two sequential years of extreme [illegible]ne of wh[illegible]e dry or critically dry. Delta smelt will be considere[illegible]g when t[illegible] meets recovery criteria under stressor conditions co[illegible]o those th[illegible]ting and mechanisms are in place that insure the spec[illegible]ed existe[illegible]

Recovery Criteria

Re[illegible]oration of delta [illegible]ld be assessed when the species satisfies distrib[illegible]onal and abundan[illegible]. Distributional criteria include: (1) catches of delta smel[illegible] all zones 2 of 5 co[illegible]ve years, (2) in at least two zones in 1 of the rem[illegible]ning 3 years, and, (3)[illegible] at least one zone for the remaining 2 years. Abundance cr[illegible]a are: delta smelt nu[illegible]bers or total catch must equal or exceed 239 for 2 out of 5 y[illegible] and not fall below [illegible] for more than two years in a row. Distributional and [illegible]ance criteria can[illegible]e met in different years. If abundance and distributional criteria [illegible] for a five-ye[illegible] period the species will be considered restored. Delta smelt will [illegible]ecovery criteria and be considered for delisting when abundance a[illegible] criteria are met for a five-year period that includes two successive ext[illegible]ow years, with one year dry or critical. Delisting is contingent on the placement of legal mechanisms and interagency agreements to manage the CVP, SWP, and other water users to meet these criteria. Both criteria depend on data collected by DFG during the FMWT, during September and October.

Justification for using FMWT numbers: The FMWT covers the entire range of delta smelt distribution and provides one of the two best measures of delta smelt abund[illegible]nce (Sweetnam and Stevens 1993). The summer tow-net survey samples juveniles o[illegible] annual species and provides another good measure of abundance. T[illegible]e FMWT [illegible] a better measure of abundance because it samples pre-spawning [illegible] delta sm[illegible] index based on pre-spawning adults, rather than on juveniles, wh[illegible] are vulnerab[illegible] high mortality, provides a better estimate of delta smelt stock an[illegible] recruitment. T[illegible] FMWT may not be as efficient at sampling delta smelt compare[illegible] with the Ko[illegible]ak trawl, which is pulled by two boats and tends to sample the upper wa[illegible] column, [illegible]ut it has been continuously done for almost 30 years (since 1967) and s[illegible]id base of historical data with known sampling error.

September and October numbers of adults were chosen, b[illegible] are the months that were sampled most consistently in all years. In ad[illegible]tion, w[illegible] smelt begin moving upstream to spawn in November and December, they occu[illegible] frequently in the FMWT. Weather conditions are also more [illegible]le in Septem[illegible] October. The more frequent storms of November and D[illegible]roduce con[illegible] that result in more variability in fish-capture numbers [illegible] correlation[illegible] between September and October numbers and to[illegible] numbe[illegible]

Number of delta smelt rather than abun[illegible]ance inde[illegible] was us[illegible]overy criteria. The abundance index was initially d[illegible]eloped fo[illegible] striped ba[illegible]umbers were chosen because delta smelt occupy the [illegible]r water c[illegible]umn. Multi[illegible]ying delta smelt captured by volume of water in the por[illegible] the est[illegible]ry sample[illegible]probably doesn't give a good representation of the number [illegible]sh presen[illegible] Using num[illegible]ers for delta smelt simplifies the assumptions of the cri[illegible]a and there [illegible]a close [illegible]respondence between numbers and [illegible]he abundance in[illegible]x f[illegible] delta sme[illegible]

Justificat[illegible]sing 19[illegible] the standa[illegible] Graphs from different surveys were use[illegible]h pre-de[illegible]ost-decline periods for delta smelt (Moyle *et al.* 1992). The s[illegible]luded were [illegible]T, (2) summer tow-net, (3) Suisun Marsh fish survey, and[illegible]ey survey [illegible]A). Each of the surveys showed slightly different patterns [illegible] The most [illegible]le trend is that delta smelt decline began earlier in the so[illegible]lta than i[illegible]e rest of the estuary (Sweetnam and Stevens 19[illegible] The pre[illegible]riod identified by Moyle *et al.* (1992) is 1967 through and inclu[illegible]g 1981; the p[illegible]period is 1982-92. Using 1982 as the beginning of the de[illegible]e period is justifie[illegible] 1982 and 1983 were very wet years and declines in de[illegible] smelt abundance c[illegible]nd to extremes in outflow: very wet and very dry yea[illegible]result in low numbers [illegible]Moyle *et al.* 1992). The mechanisms for this are that delta sm[illegible] larvae are washed d[illegible]wnstream of favorable nursery grounds in wet years; dry y[illegible] decrease spawning [illegible]abitat and move adults and juveniles upstream into less [illegible]ctive deep river c[illegible]nnels where they are more at risk to entrainment in water [illegible]

[illegible]atives were proposed for the decline period. One possibility was to us[illegible]e beginning of the decline period because it was a dry year followed by the wet year 1982. The occurrence of a dry year followed by a wet year produces a double stress on delta smelt and this may have been the true beginning of the decline.

An argument can also be made for using 1983 as the beginning of the decline: this is the year that delta smelt declined in the FMWT and so is consistent with other recovery criteria (which is based on the FMWT). There is a noticeable change in geographic distribution of delta smelt in 1982 and 1983, which corresponds to the periods use[illegible] in the Biological Opinion and the decline in FMWT numbers, respectively. The decl[illegible] delta smelt numbers actually occurred over a multi-year period from [illegible]81-1983 [illegible] midpoint of this period, 1982, was used as the beginning of the de[illegible]

Justification for including distributional recovery criteria: G[illegible]graphical di[illegible]butio[illegible] and numbers of fish were used to measure recovery because r[illegible]overy of de[illegible] smelt should include a restoration of the species to portions of their f[illegible]er range. Before 1982, delta smelt were captured at an average of 19 FMWT sta[illegible]fter 1981 they were captured at an average of 10 stations. From 1986-1992, th[illegible]melt population was concentrated in the lower Sacramento River between Collins[illegible]io Vista (Sweetnam and Stevens 1993). Historically, when delta smelt we[illegible]dant, the population was spread from Suisun Bay and Montezuma Slou[illegible] throug[illegible]ta. The shallow, productive waters of Suisun Bay and Suisun Marsh are importan[illegible]r delta smelt. Large percentages of delta smelt catches are i[illegible]isun Bay wh[illegible] are sufficient to maintain the mixing zone and salinities [illegible] per thousa[illegible]hat area. When concentrated in deep river channels du[illegible]igh salinitie[illegible] Suisun Bay, delta smelt are more vulnerable to e[illegible]ainment [illegible] project facilities, predation and other risks.

FMWT stations chosen to measure recov[illegible]y: Statio[illegible] chosen f[illegible]covery criteria were sampled in every year (that the FM[illegible] was cond[illegible]cted) and [illegible]d a record of delta smelt catches. Occasionally, this was [illegible]ed to in[illegible]de stations sampled in all years but one (stations 509, 511, 602). The [illegible]l number [illegible] stations is [illegible]5 and there is a strong correlation between delta smelt at **th[illegible]e stations** [illegible] total n[illegible]bers of delta smelt (r = 0.94).

Zone A ([illegible]ntral De[illegible]
11 station[illegible]
802 804 806 [illegible]12 814 90[illegible]908

Zone B1 (Sacram[illegible]r)
5 stations
701 703 70[illegible]7 709

Zone B[illegible] (Montezuma Slo[illegible]
4 sta[illegible]ns
60[illegible]04 606 608

Z[illegible] C (Suisun Bay)
[illegible]tions
[illegible]2 414 416 41[illegible] [illegible]01 503 505 507 509 511 513 515 517 519

[illegible]teria: Distributional criteria were developed on the basis of number of sta[illegible]ch zone where delta smelt were captured during the predecline period (Tables 2.2, 2.3, Figures 2.7 and 2.8). Each zone has the following criteria: (1) in Zone A, delta smelt must be captured in 2 of 11 sites; (2) in Zone B (includes B1 and B2),

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delta smelt must be captured in 5 of 9 sites, and (3) in Zone C, delta smelt must be captured in 6 of 15 sites. Criteria for all zones need to be met in all years. Criteria for recovery are as follows: (1) site criteria must be met in all zones 2 of 5 consecutive years, (2) in at least two zones in 1 of the remaining 3 years, and, (3) in at least one zone for the remaining 2 years. A failure in all zones in any year will result in the [illegible] of a new 5-year evaluation period for the distributional criteria. Failure to meet these criteria in consecutive years should be avoided because such conditions will place [illegible] species in danger of extinction. These distributional criteria will be met in concert [illegible] the abundance criteria.

Abundance criteria: Abundance of delta smelt constituting recovery is based on pre-decline delta smelt numbers from the FMWT (Table 2.3). Two numbers were identified that had to be met during the five-year recovery period: (1) a low [illegible] below which abundance can not fall for more than two years in a row and, (2) a [illegible]ber to be reached or exceeded in two out of five years. A low number was [illegible]tect delta smelt from the risk of extinction during prolonged droughts or extremes [illegible]. The lowest two-year running average of abundance in the pre-decline years w[illegible] the low number. A running average was used because of the great degree [illegible] in delta smelt abundance. The high number is the medi[illegible] smelt abun[illegible] pre-decline years, in other words, abundance of del[illegible] time in the pre-decline period. To meet recovery criteria, delta smelt abund[illegible] meet or exceed 239 in two out of five years and the two-year running average [illegible] below 84. If any of these conditions are not met, the five-year recovery perio[illegible] again.

Length of restoration and recovery pe[illegible]: Delta smelt generation time and frequency of occurrence of very dry an[illegible] wet years were used to determine appropriate length of the restoration period. Because delta smelt live only a year, a five-year recovery period would include f[illegible] generations of delta smelt; five generations is comparable to the period used in recovery plans [illegible]es. A five-year restoration period has a [illegible]sonable prob[illegible] including [illegible] extreme outflow. The 40:30:30 [illegible]: Year-ty[illegible]es adopted by the SWRCB in the 1991 Salinity Control P[illegible]mento Riv[illegible] (SRI) from 1906-1992 was used for this analysis. Th[illegible] to identify [illegible]at had a high probability of including two extreme outflo[illegible]eferably b[illegible]. This method was chosen because when two extreme[illegible]ur togeth[illegible] smelt are at risk of extinction. Because extremes in out[illegible]isting of the delta smelt, the period identified for recovery differs from restoration [illegible]es a stressor period. Delta smelt will be considered for delisting when abundance [illegible]butional criteria have been met over a five-year period that includes two se[illegible]ears of extreme outflows. However, delisting may not take place until there is [illegible]able assurance that long term solutions to delta problems are in place. One of the extreme years must be dry or critically dry (SRI $\leq$ 6.0); the other can be wet SRI [illegible]11.2). Other indices can be used to identify dry, critically dry, a[illegible]wet years, if appropriate. Dry conditions are included because delta smelt losses [illegible]se in dry and critical years due to high proportions of outflow diverted, which [illegible] in habitat loss and increased entrainment in water projects. Analysis of the [illegible] hydrogr[illegible] indicated that there is about a 24 percent chance that two extreme y[illegible]ry or critical) will occur in a five-year period. There is a 48 percent ch[illegible]d on the historical hydrograph) that the period of time required to delist delta smelt could be 10 years. According to existing records, the longest amount of time required to delist delta smelt is 38 years.

Table 2.2 Number of sites with delta smelt from FMWT September and October numbers for 35 stations. Numbers in brackets refer to station numbers. The FMWT did not sample in 1974 and 1979. See Figure 2.8 for how minimum number of sites was determined.

	Sites		
Year	Zone C Suisun Bay (410-519)	Zone B Montezuma Slough Sacramento River (602-709)	Zone A North Central Delta (802-908)
		Pre-decline	
1967	6	8	2
1968	9	6	8
1969	11	7	0
1970	12	8	7
1971	13	8	8
1972	12	8	9
1973	9	9	4
1975	12	5	5
1976	1	5	2
1977	0	5	5
1978	11	6	0
1980	10	8	3
1981	8	6	[illegible]
Minimum number of sites	6 of 15	5 of 9	2 of [illegible]
Number of years minimum number of sites occurred	11 out of 13	13 of [illegible]	10 of 13
		Po[illegible]ecline	
1982	6	6	1
1983	5	4	[illegible]
1984	9	[illegible]	[illegible]
198[illegible]	[illegible]	[illegible]	[illegible]
19[illegible]	[illegible]	[illegible]	1
1987	[illegible]	[illegible]	1
1988	[illegible]	[illegible]	0
1989	[illegible]	5	3
1990	4	6	0
1991	[illegible]	6	3
1992	[illegible]	5	1
1993	12	[illegible]	4
19[illegible]*	**1**	[illegible]	**1**
[illegible]95*	**14**	[illegible]	**1**
1996*	**8**	[illegible]	**2**
1997*	**3**	**4**	**1**
Nu[illegible]er of years mi[illegible]um number of s[illegible]ccurred	7 out of 1[illegible]	9 of 16	4 of 16

Table 2.3 Numbers used for delta smelt abundance criteria. Numbers are from the September and October FMWT for 35 stations. The FMWT did not sample 1974 and 1979.

Year	Number	Two-year running average .
	Pre-decline	
1967	139	
1968	251	195
1969	128	190
1970	589	359
1971	352	471
1972	551	452
1973	305	428
1975	**239**	272
1976	22	131
1977	146	**84**
1978	108	127
1980	312	210
1981	78	195
	Post-decline	
1982	37	58
1983	17	[illegible]
1984	51	[illegible]
1985	29	40
1986	70	50
1987	72	71
1988	43	58
1989	76	6[illegible]
1990	81	[illegible]9
1991	171	126
1992	26	98
1993	400	213
1994*	**19**	**210**
1995*	**255**	[illegible]
1996*	**28**[illegible]	[illegible]
199[illegible]	[illegible]	[illegible]**4****

*** - Criteria u**[illegible]**97**
**** - Two-Year R**[illegible]**rage below** [illegible]